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■

AIR POLLUTION

Heavy Duty Engines

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 86]

[FRL 528-8]

CONTROL OF AIR POLLUTION FROM NEW MOTOR VEHICLES AND NEW MOTOR VEHICLE ENGINES: CERTIFICATION AND TEST PROCEDURES

Revised Heavy Duty Engine Regulations for 1979 and Later Model Years

The Environmental Protection Agency (EPA) is considering amendments to Subparts A and I of Part 86 of Title 40 of the Code of Federal Regulations. In addition, a new Subpart D combining previous Subparts H and J has been developed. These amendments set new standards for heavy duty gasoline-fueled and Diesel engines, revise the section numbering to reflect applicability to the 1979 and later model years, and also revise parts of the current test procedures.

In spite of the gains made in control of air pollution there are many air quality control regions which will not be able to meet ambient air quality standards. Motor vehicles contribute a large percentage of the total hydrocarbons, carbon monoxide and oxides of nitrogen contaminants. As standards on light duty vehicles and light duty trucks are made more stringent, a larger portion of these pollutants will come from heavy duty vehicles.

Standards are proposed beginning with the 1979 model year for both gasoline-fueled and Diesel heavy duty engines of 1.5 gms/BHP-hr. hydrocarbon (HC), 25 gms/BHP-hr. carbon monoxide (CO), and 10 gms/BHP-hr. hydrocarbon plus oxides of nitrogen (HC+NOx). Current standards are 16 gms/BHP-hr. HC+NOx and 40 gms/BHP-hr. CO without a separate HC requirement. Additionally, a Diesel engine peak smoke opacity standard of 35 percent instead of the present 50 percent standard is proposed to prevent degradation in on the road smoke levels as a result of changes in gaseous emissions standards. Nearly all currently certified engine families have demonstrated smoke levels at or below 35 percent peak opacity. Acceleration and lugging mode Diesel smoke standards of 20 and 15 percent are unchanged by the proposal.

Test procedure revisions include the substitution of more accurate instrumentation for measurement of gasoline-fueled engine HC and both gasoline-fueled and Diesel NOx measurements; the addition of specific calibrations and maintenance procedures; and minor revisions to the test cycles.

This action is forecast to result in a reduction in 1990 nationwide emissions of 0.6 to 0.7 million tons HC, up to 1.8 million tons CO, and 0.4 to 1.0 million tons of NOx. These reductions correspond to urban air quality improvements of 1 to 4 percent for oxidants, 1 percent for carbon monoxide and 1 to 4 percent for nitrogen dioxide.

The retail price for heavy duty trucks is expected to increase approximately $110 for gasoline-fuel vehicles and 120 for Diesel vehicles. The aggregate five year cost of the proposal is forecast to be $378 million.

An evaporative HC standard is not a part of the proposed regulations. This is because an adequate test procedure, such as the enclosure (SHED) method, has not been fully developed for application to heavy duty vehicles. Further, a comprehensive compliance assurance mechanism to deal with vehicles rather than engines alone has not been established.

EPA believes that the proposed emission levels are achievable with current, production proven technology. A lead time of one year should be sufficient to incorporate this technology into production engines. Further, it is expected that engines meeting the proposed standards need not suffer any loss in fuel economy if already demonstrated fuel efficient technology is employed. The standards proposed were selected because they represent a significant and cost effective reduction in emission levels, especially HC, obtainable in the short term without use of catalyst or costly and unproven technology.

A separate HC standard is included in the proposed regulations. Test measurements of HC correspond well with actual on the road emissions, and an individual standard plus a combined HC and NOx standard will give incentive for HC control. This necessary control will be effective in reducing atmospheric oxidant levels.

Certain modifications to certification practices are proposed. The requirement that the Administrator specify the engine displacement with the highest projected sales within a control system for durability testing has been eliminated. This provision unnecessarily limited the Administrator's ability to require a showing that a particular displacement could meet the requirements of the regulations.

Maintenance provisions for gasoline-fueled and Diesel engines have been modified to include EGR systems and catalytic converters. Essentially, light duty vehicle regulations on these topics have been modified to apply to heavy duty engines. Neither the use of EGR systems or catalytic converters are considered necessary to meet the proposed standards. However, if used, warning devices to alert the engine operator to the need for EGR or catalyst maintenance are required, and the conditions under which maintenance may be performed are specified.

The "zero hour" emission test is no longer required nor allowed. Manufacturers will continue to be required to supply information on components used on certification engines prior to service accumulation in order to assure that these engines are representative of engines intended for production.

Specifications for service accumulation gasoline have been modified to more accurately reflect commercially available fuel. The minimum lead and phosphorus content requirements for unleaded fuel have been deleted. Sensitivity (research minus motor octane) must be at least 8 octane numbers. Some of these changes were previously made in the light duty vehicle regulations. EPA believes that the same fuel specifications should apply to heavy duty engines, with the one exception that Reid vapor pressure corresponding to seasonal fuel changes will not be required since heavy duty engine testing is normally performed under controlled ambient conditions.

Several changes have been made to the test cycle for gasoline-fueled engines. A change to engine torque to define the various operating modes (instead of engine manifold vacuum) for the 9-mode test is most significant. This was necessary to accommodate supercharged engines which do not operate under vacuum conditions in all modes. Also, engines utilizing EGR have widely varying vacuums for a given power setting. Data from 19 representative engines were statistically analyzed in arriving at equivalent percent torque set points corresponding to the current manifold vacuum set points. Values of 10, 25, 55, and 90% of maximum observed torque were derived to replace the manifold vacuum levels of 19, 16, 10, and 3 inches of mercury. The test cycle as modified closely corresponds to the existing 9-mode cycles. Only the definition of the operating points has been changed.

Although the emission test has been defined in terms of torque, service accumulation can be carried out under manifold vacuum, manifold pressure or torque control. The manufacturer will be required to select a method and then notify EPA. This option was included to allow flexibility in instrumentation and control systems.

Two other related changes in the 9-mode test procedures have been made. First, time in mode has been increased to a uniform 60 seconds for each mode. Second, the number of cycles per test has been reduced from four to two. As a consequence, the overall test is approximately the same length. Any loss in test repeatability from fewer cycles is compensated by increased measurement time available during each cycle. These changes were made to give the test operator time to determine proper instrument ranges and to take all required readings. Even though mode times are changed, the prior weighting factors are retained. EPA testing indicates that these revisions do not significantly affect average test results.

Several significant changes for both gasoline-fueled and Diesel engine sampling and analytical systems have been proposed. Hydrocarbons (HC) will be measured by a heated flame ionization detector (HFID) replacing the present non-dispersive infrared (NDIR) analyzer used in testing gasoline-fueled engines. The Diesel test procedure already uses an HFID. The FID is more accurate and stable, and has a linear response. The requirement for a heated instrument will eliminate water condensation and exhaust sample condensation (hang-up) difficulties. Because HFIDs are more sensitive than

current analyzers, the proposed standards have been adjusted to reflect the change in instrumentation. In addition, a carbon dioxide measurement by NDIR is now required for Diesel engines to provide a basis for calculating and comparing air fuel ratio to measured values. Carbon dioxide data are also used in calculating the total mass of exhaust.

Oxides of nitrogen will be measured by a CL analyzer instead of the current NDIR instruments. The CL analyzer, when coupled with a reducing converter, will measure total oxides of nitrogen ($NO + NO_2$) and not just nitric oxide (NO) as is the case with the current NDIR analyzers. Since more than one compound is to be measured, it would appear that any total nitrogen oxides instrument would give higher concentrations than an instrument that only measures NO. However, since the CL analyzer is not subject to interference from water vapor and carbon dioxide it may give a slightly lower, but more accurate, total reading than the current NDIR instrument.

Coincidental with the change in analyzers the exhaust sample conditioning and transport system has been modified. These revisions in line length, transit time, arrangements, heating requirements, etc. are necessary to insure sample integrity and accurate results. Calibration procedures and instrument checks have been revised accordingly. Variations in either the instruments or analytical system are permissible. However, prior EPA approval based on proven equivalency is necessary before a modified system can be used.

Test data requirements have been expanded. Fuel temperature, humidity, air temperature, and fuel hydrogen to carbon ratio must now be supplied. These data are needed to calculate a correction factor to account for water vapor in the HFID sample. Currently, engine air flow is measured for diesel engines and not for gasoline-fueled engines. The air flow measurement of gasoline-fueled engines is now being proposed. This will provide a basis for calculating the wet to dry sample correction factor (Kw) and will also be used in computing a measured air fuel ratio to be compared to the air fuel ratio calculated from the exhaust gas constituents. This will serve as the only overall system quality control check. Measured and calculated values must agree within 10% for a valid test.

EPA recognizes that this requirement is an additional burden for the gasoline-fueled engine manufacturers and testing laboratories. However, the confidence in test accuracy which a system quality control mechanism provides is an overriding consideration.

There may, of course, be other methods of accomplishing the quality control objectives such as use of a tracer gas. However, EPA has no experimental experience with such a method as applied to heavy duty engines. EPA invites the submission of data on alternative quality control mechanisms as well as on the use of measured and calculated air flow for this purpose. If a less complicated, but equally comprehensive total system check is available, EPA will consider it as an alternative to, or replacement for, the air flow measurement requirement in final rulemaking.

Preconditioning for gasoline-fueled engine tests now begins with an engine that is warmed up at progressively higher loads until maximum torque is determined. As in current practice, the engine must be allowed to stand for one to two hours at 25±5°C prior to the actual test. Each test consists of a 5 minute idle followed by two 9-mode cycles. Each mode is one minute long and exhaust gases are evaluated over the last 10 seconds (50 seconds for the closed throttle). Only one significant change has been made in the Diesel 13-mode test cycle. The time in mode has been reduced from 10 minutes per mode to 5 mintues per mode to significantly reduce the time required to complete an entire test. Manufacturers are invited to supply data on the effect of reduced mode time on emission levels, if any, and to comment on any resource savings which may result.

Emission level calculations for CO, CO_2 and NOx are made on a dry basis (i.e., with water vapor removed); a correction is applied to the wet HC measurements. Chart reading requirements have been clarified and computers or other devices may be substituted for manual monitoring if they meet the requirements of the pertinent subpart.

All Diesel engine test procedures are now contained in the proposed regulations. References to Society of Automotive Engineers practices have been eliminated and the required procedure is now fully stated in the regulations.

Diesel fuel specifications for service accumulation have been revised. The revised fuel specification should make service accumulation fuel easier to obtain and should also better reflect the composition of commercially available fuel.

It is unlikely that carry-over emission data will be allowed for certification because of the standards changes coupled with extensive revisions to the analytical measurement system which now measures total NOx. Only nitrous oxide (NO) was measured previously.

In summary, the proposed regulations make more stringent the emission standards applicable to 1979 and later model year heavy duty engines. EPA believes that these standards are feasible, will result in no fuel penalty, and can be met without the use of catalysts. Without more stringent controls on all motor vehicles many Air Quality Control Regions will be unable to meet ambient air quality standards. Along with new standards, improvements in test procedures and equipment are also proposed.

Recently EPA has received information that suggests that some manufacturers may be contemplating the development of Diesel engines for use in vehicles that fall into the lower part of the weight range of vehicles classified as heavy duty, which vehicles are currently almost exclusively powered by gasoline engines. EPA is concerned about the appropriate testing of such engines because the current heavy duty Diesel durability test schedule, which is much more severe than the heavy duty gasoline test schedule, may hinder the introduction of lighter duty Diesel engines for applications in lighter trucks currently powered by gasoline engines. EPA hereby requests comments and suggestions on a means of defining this emerging new class of engines, as well as on a test protocol appropriate for the testing of these engines.

Relevant comments, views, suggestions and data from any individual or group on pertinent topics will be considered in drafting final regulations.

40 CFR, Part 86, as amended would become effective 30 days after publication and would be applicable to 1979 and subsequent model year heavy duty engines. The current regulations which appear in 40 CFR, Part 85 and Part 86 would remain in effect for 1974 through 1978 model year engines.

Interested persons may submit written data, views, or arguments (in quadruplicate) to the Administrator, Environmental Protection Agency, Attention: Office of Mobile Source Air Pollution Control (AW-455), 401 M Street, S.W., Washington, D.C. 20460. All relevant material received not later than August 23, 1976 will be considered. Comments submitted shall be available for public inspection during normal business hours at the Environmental Protection Agency, Public Information Reference Unit, Room 2922 (EPA Library), 4th and M Streets, S.W., Washington, D.C. 20460.

A Document entitled "An Examination of Interim Emission Control Strategies for Heavy Duty Vehicles" which describes the need for additional control and the technical development of proposed standards is available from the Director, Emission Control Technology Division, 2565 Plymouth Road, Ann Arbor, Michigan 48105.

Single copies of the Draft Environmental Impact Statement for this regulation are available upon request from the Public Information Center (PM-215), U.S. Environmental Protection Agency, Washington, D.C. 20460. The Draft Environmental Impact Statement discusses the environmental and economic impacts of the proposed regulation.

This notice of proposed rulemaking is issued under the authority of sections 202, 206, 207, 208 and 301(a) of the Clean Air Act, as amended (42 U.S.C. 1857f-1, 1857f-5, 1857f-5a, 1857f-6 and 1857g(a)).

It is hereby certified that the economic and inflationary impacts of this proposed regulation have been carefully evaluated in accordance with Executive Order 11821.

Dated: May 7, 1976.

JOHN QUARLES,
Acting Administrator.

It is proposed to amend 40 CFR Part 86 as follows:

1. A new section 86.079–2 is added and reads as follows:

§ 86.079–2 Definitions.

The following definitions apply beginning with the 1979 model year. Other portions of § 86.077–2 remain effective.

"Gross vehicle weight rating" (GVWR) means the value specified by the manufacturer as the maximum design loaded weight of a single vehicle.

"Hang-up" means any hydrocarbon molecules that are absorbed, adsorbed, condensed, or by any other method removed from the sample flow prior to reaching the instrument detector.

"Intermediate speed" means peak torque speed if peak torque speed occurs between 60 and 75 percent of rated speed. If the peak torque speed is outside of these specifications, intermediate speed is defined as 60 percent of rated speed.

"Turn down ratio" means the ratio of the minimum detectable quantity to the maximum detectable quantity.

2. A new section 86.079–10 is added and reads as follows:

§ 86.079–10 Emission standards for 1979 gasoline-fueled heavy duty engines.

(a)(1) Exhaust emissions from new 1979 and later model year gasoline-fueled heavy duty engines shall not exceed:

(i) *Hydrocarbons.* 1.5 grams per brake horsepower hour.

(ii) *Carbon monoxide.* 25 grams per brake horsepower hour.

(iii) *Hydrocarbons plus oxides of nitrogen.* 10 grams per brake horsepower hour.

(2) The standards set forth in paragraph (a)(1) of this section refer to a composite sample representing the operating cycle set forth in subpart D and measured in accordance with those procedures.

(b) (Reserved)

(c) (See paragraph (c) of § 86.077–10).

(d) Every manufacturer of new motor vehicle engines subject to the standards prescribed in this subpart shall, prior to taking any of the actions specified in section 203(a)(1) of the Act, test or cause to be tested motor vehicle engines in accordance with test procedures prescribed in subpart D to ascertain that such test engines meet the requirements of paragraphs (a) and (c) of this section.

3. A new section 86.079–11 is added and reads as follows:

§ 86.079–11 Emissions standards for 1979 Diesel heavy duty engines.

(a)(1) The opacity of smoke emissions from new 1979 and later model year Diesel heavy duty engines shall not exceed:

(i) 20 percent during the engine acceleration mode.

(ii) 15 percent during the engine lugging mode.

(iii) 35 percent during the peaks in either mode.

(2) The standards set forth in paragraph (a)(1) of this section refer to exhaust smoke emissions generated under the conditions set forth in Subpart I and measured and calculated in accordance with those procedures.

(b)(1) Exhaust gaseous emissions from new 1979 and later model year Diesel heavy duty engines shall not exceed:

(i) *Hydrocarbons.* 1.5 grams per brake horsepower hour.

(ii) *Carbon monoxide.* 25 grams per brake horsepower hour.

(iii) *Hydrocarbons plus oxides of nitrogen.* 10 grams per brake horsepower hour.

(2) The standards set forth in paragraph (b)(1) of this section refer to exhaust gaseous emissions generated under the conditions set forth in subpart D and measured and calculated in accordance with those procedures.

(c) through (d) (See paragraphs (c) through (d) of § 86.077–11).

(e) Every manufacturer of new motor vehicle engines subject to the standards prescribed in this subpart shall, prior to taking any of the actions specified in section 203(a)(1) of the Act, test or cause to be tested motor vehicle engines in accordance with test procedures prescribed in subparts D and I to ascertain that such test engines meet the requirements of paragraphs (a) and (b) of this section.

4. A new section 86.079–23 is added and reads as follows:

§ 86.079–23 Required data.

The manufacturer shall perform the tests required by the applicable test procedures, and submit to the Administrator the following information:

(a) Durability data on such vehicles (or engines) tested in accordance with the applicable test procedures and in such numbers as specified, which will show the performance of the systems installed on or incorporated in the vehicle (or engine) for extended mileage (or extended operation), as well as a record of all pertinent maintenance (all maintenance and servicing for heavy duty engines) performed on the test vehicles (or test engines). Maintenance and servicing of heavy duty engines performed prior to the zero hour point need not be submitted.

(b) through (b)(1)(ii) (See paragraphs (b) through (b)(1)(ii) of § 86.077–23).

(2) Certification engines. Emission data on such engines tested in accordance with applicable emission test procedures and in such numbers as specified, which will show their emissions after 125 hours of operation.

(c)(1) (See paragraph (c)(1) of § 86.077–23).

(2) For heavy duty engines, a statement that engines for which certification is requested conform to the requirements in § 86.077–5(b) and that the descriptions of tests performed to ascertain compliance with the general standards in § 86.077–5(b) and the data derived from such tests are available to the Administrator upon request.

(d)(1) For light duty vehicles and light duty trucks, a statement that the test vehicles with respect to which data are submitted have been tested in accordance with the applicable test procedures, that they meet the requirements of such tests, and that, on the basis of such tests, they conform to the requirements of the regulations in this part. If such statements cannot be made with respect to any vehicle tested, the vehicle shall be identified, and all pertinent test data relating thereto shall be supplied.

(2) For heavy duty engines, a statement that the test engines with respect to which data are submitted to demonstrate compliance with § 86.077–11 are in all material respects as described in the manufacturer's application for certification, have been tested in accordance with the applicable test procedures utilizing the fuels and equipment described in the application for certification, and that on the basis of such tests the engines conform to the requirements of the regulations in this part. If such statements cannot be made with respect to any engine tested, the engine shall be identified, and all pertinent data relating thereto shall be supplied to the Administrator. If, on the basis of the data supplied and any additional data as required by the Administrator, the Administrator determines that the test engine was not as described in the application for certification or was not tested in accordance with applicable test procedures utilizing the fuels and equipment as described in the application for certification, the Administrator may make the determination that the engine does not meet the applicable standards. The provisions of § 86.077–30(b) shall then be followed.

5. A new section 86.079–24 is added and reads as follows:

§ 86.079–24 Test vehicles and engines.

(a)(1) through (a)(2)(iv) (See paragraphs (a)(1) through (a)(2)(iv) of § 86.077–24.)

(v) The location of intake and exhaust valves (or ports) and the valve (or port) sizes (within a ⅛-inch range on the valve head diameter).

(a)(2) (vi) and (vii) (See paragraphs (a)(2) vi) and vii) of § 86.077–24).

(viii) Catalytic converter characteristics.

(ix) Thermal reactor characteristics.

(x) Air inlet cooling characteristics. (e.g., inter-coolers and after-coolers) for Diesel heavy duty engines.

(a)(3) through (g)(4) (See paragraphs (a)(3) through (g)(4) of § 86.077–24).

6. A new section 86.079–25 is added and reads as follows:

§ 86.079–25 Maintenance.

(a) and (b) (See paragraphs (a) and (b) of § 86.077–25)

(c)(1) *Heavy duty engines.* Paragraph (c) of this section applies to heavy duty engines.

(2)(i) The scheduled maintenance described in this section may be performed on a durability engine provided the maintenance is requested in the application for certification and is specified

at the same intervals in the maintenance instructions which will be furnished to the ultimate purchaser of the vehicle in which the engine, which is represented by the test engine, is installed. (For equivalent dynamometer hours, engine hours, and mileage intervals, see § 86.-077-2.) A scheduled major engine servicing shall be restricted to items listed in this subparagraph and shall be conducted in a manner consistent with service instructions and specifications provided by the manufacturer for use by the customer service personnel.

(A) For gasoline-fueled engines, major engine tuneups to manufacturer's specifications may be performed no more frequently than every 375 hours of scheduled dynamometer operation, provided no tuneups are performed after 1375 hours of scheduled dynamometer operation. The following items may be inspected, replaced, cleaned, adjusted and/or serviced as required:

(*1*) Ignition system.

(*2*) Cold starting enrichment system (includes fast idle speed setting).

(*3*) Curb idle speed and air/fuel mixture.

(*4*) Drive belt tension on engine accessories.

(*5*) Valve lash.

(*6*) Inlet air and exhaust gas control valves.

(*7*) Engine bolt torque.

(*8*) Spark plugs.

(*9*) Fuel filter and air filter.

(*10*) Crankcase emission control system.

(*11*) Fuel evaporative emission control system.

(B) For Diesel engines one major engine servicing to the manufacturer's specifications may be performed prior to 875 hours (±8 hours) of scheduled dynamometer operation. The following items may be inspected, replaced, cleaned, adjusted, and/or serviced as required:

(*1*) Low idle speed.

(*2*) Drive belt tension.

(*3*) Engine bolt torque.

(*4*) Valve lash.

(*5*) Injection timing.

(*6*) Injector assemblies.

(*7*) Governor settings.

(C) Normal engine servicing such as engine oil change, and oil filter, fuel filter, and air filter cleaning or replacement will be allowed at manufacturer's recommended intervals. If approved in advance by the Administrator, the maintenance for these items may differ from that specified in the manufacturer's maintenance instructions.

(D) Readjustment of the engine low idle speed may be performed once during the first 125-hours of engine operation.

(ii) Unscheduled maintenance may be performed on durability engines, except as provided in paragraph (c)(2)(v)(A) of this section, only under the following provisions:

(A) An injector or spark plug may be changed if a persistent misfire is detected.

(B) Readjustment of a gasoline-fueled engine cold starting enrichment system may be performed if there is a problem of stalling or if there is visible black smoke.

(C) Readjustment of the engine idle speed (curb idle and fast idle) may be performed, in addition to that performed as scheduled maintenance under subparagraph (c)(2)(i) of this section, if the idle speed exceeds the manufacturer's recommended idle speed by 300 r.p.m. or more, or if there is a problem of stalling.

(D) The idle mixture may be reset, other than during scheduled major engine tuneups, only with the advance approval of the Administrator.

(iii) Any exhaust gas recirculation (EGR) system may be serviced during durability testing only under one of the following provisions:

(A) Manufacturers may schedule service to the EGR system at the scheduled major engine tuneup if an audible and/or visual signal approved by the Administrator alerts the engine operator to the need for EGR system maintenance at the service point. One additional servicing may also be performed as unscheduled maintenance if there is an overt indication of malfunction and if the malfunction or repair of the malfunction does not render the test engine unrepresentative of engines in use.

(B) Manufacturers may service the EGR system as unscheduled maintenance a maximum of one time during durability testing (1500 hours for gasoline-fueled engines or 1000 hours for Diesel engines) if failure of the EGR system activates an audible and/or visual signal approved by the Administrator which alerts the engine operator to the need for EGR system maintenance. One additional servicing may also be performed as unscheduled maintenance if there is an overt indication of malfunction and if the malfunction or repair of the malfunction does not render the test engine unrepresentative of engines in use.

(C) Manufacturers may service the EGR system a maximum of three times during durability testing (1500 hours for gasoline-fueled engines or 1000 horus for Diesel engines) either at a scheduled major engine tuneup point or as unscheduled maintenance, if an audible and/or visual signal approved by the Administrator alerts the engine operator to the need for EGR system maintenance. The signal may be activated either by EGR system/failure (unscheduled maintenance) or need for scheduled periodic maintenance. If maintenance is performed, the signal for scheduled periodic maintenance shall be reset. One additional servicing may also be performed as unscheduled maintenance if there is an overt indication of mulfunction and if the malfunction or repair of the malfunction does not render the test engine unrepresentative of engines in use.

(D) Manufacturers may schedule service to the EGR system at the scheduled major engine tuneup(s) if failure to perform EGR system maintenance is not likely, as determined by the Administrator, to result in an improvement in engine performance. One additional servicing, may also be performed as unscheduled maintenance if there is an overt indication of malfunction and if the malfunction or repair of the malfunction does not render the test engine unrepresentative of engines in use.

(iv) The catalytic converter may be serviced once during durability testing (1500 hours of gasoline-fueled engines or 1000 hours for Diesel engines) if an audible and/or visual signal approved by the Administrator alerts the engine operator to the need for maintenance. The signal may be activated either by component failure or need for maintenance at a scheduled point.

(v) Any other engine, emission control system, or fuel system adjustment, repair, removal, disassembly, cleaning, or replacement on durability engines shall be performed only with the advance approval of the Administrator.

(A) In the case of unscheduled maintenance such approval will be given if the Administrator:

(*1*) Has made a preliminary determination that part failure or system malfunction, or the repair of such failure or malfunction, does not render the engine unrepresentative of engines in use, and does not require direct access to the combustion chamber, except for fuel injection component, or removable prechamber removal or replacement; and

(*2*) Has made a determination that the need for maintenance or repairs is indicated by an overt indication of malfunction such as persistent misfire, engine stall, overheating, fluid leakage, loss of oil pressure, excessive fuel consumption or excessive power loss.

(B) Emission measurements may not be used as a means of determining the need for unscheduled maintenance under subparagraph (c)(2)(v)(A)(*1*).

(C) Requests for authorization of scheduled maintenance of emission control related components not specifically authorized to be maintained by these regulations must be made prior to the beginning of durability testing. The Administrator will approve the performance of such maintenance if the manufacturer makes a satisfactory showing that the maintenance will be performed on engines in use.

(vi) If the Administrator determines that part failure or system malfunction occurrence and/or repair rendered the engine unrepresentative of engines in use, the engine shall not be used as a durability engine.

(3)(i) Scheduled maintenance on emission data engines is limited to the adjustment of idle speed once before the 125-hour test point, provided the idle speed is outside the manufacturer's specifications.

(ii) Any other engine, emission control system, or fuel system, adjustment, repair, removal, disassembly, cleaning, servicing, or replacement shall be performed only with the advance approval of the Administrator.

(4) [Reserved]

(5) (i) Complete emission tests (see subpart D for gasoline-fueled engines and subparts D and I for Diesel engines) are required, unless waived by the Administrator, before and after:

(A) Scheduled maintenance approved for durability engines.

(B) Unscheduled maintenance which may reasonably be expected to affect emissions.

(ii) The tests before and after scheduled maintenance, which are performed on durability engines prior to 117 hours, are waived. The test before scheduled maintenance, which is performed on durability engines after 117 hours and prior to 133 hours, is waived. The after maintenance test must be run and the results used in the deterioration factor calculation in accordance with § 86.079–28.

(iii) The idle speed reset and any scheduled maintenance on the emission-data engine shall be performed prior to the 125 hour test. The before-maintenance and after-maintenance tests associated with idle speed reset and scheduled maintenance on the emission-data engine are waived.

(iv) Test data required by this paragraph shall be air posted to the Administrator within 72 hours of test completion (or delivered within 5 working days), along with a complete record of all pertinent maintenance.

(v) When unscheduled maintenance is approved, a preliminary engineering report, unless waived by the Administrator, shall be supplied within three working days. A final engineering report shall be delivered within ten working days after the completion of the emission tests. The Administrator may approve an extension of the time requirements for the final engineering report.

(vi) All test data, maintenance reports, and required engineering reports shall be compiled and provided to the Administrator in accordance with § 86.079–23.

(6) The Administrator shall be given the opportunity to verify the existence of an overt indication of part failure and/or engine malfunction (e.g., misfire, stall).

(7) Equipment, instruments, or tools may not be used to identify malfunctioning, maladjusted, or defective engine components unless the same or equivalent equipment, instruments, or tools will be available to dealerships and other service outlets and

(i) Are used in conjunction with scheduled maintenance on such components,

(ii) Are used subsequent to the identification of an engine failure or malfunction, as provided in subparagraph (c)(2)(v)(A) of this section for durability engines or paragraph (c)(3) of this section for emission data engines, or

(iii) Unless specifically authorized by the Administrator.

7. A new section 86.079–26 is added and reads as follows:

§ 86.079–26 Mileage and service accumulation; emissions measurements.

(a) [See paragraph (a) of § 86.077–26]

(b)(1) Paragraph (b) of this section applies to heavy duty engines.

(2) (i) For gasoline-fueled engines, the dynamometer service accumulation schedule will consist of several operating conditions which give the percent loads and the modes as specified in the following chart. The percentage of times in each mode must be held within the limits specified. The maximum observed torque for each mode in the service accumulation cycle, must be determined at the rpm at which the mode is being conducted. The percent load for that mode will be determined from the maximum torque at the rpm the mode is being conducted.

Mode	Observed torque (percent of maximum observed)	Percentage of time
Idle	Idle	23(22–24)
Closed throttle (CT)	CT	31(30–32)
Part throttle deceleration (PTD)	10	15(14–16)
Cruise	25	6(5– 7)
Part throttle escalation (PTA)	55	11(10–12)
Full load (FL)	90	14(13–15)

(ii) The equivalent control parameter for engine loading will be manifold vacuum, manifold pressure, or torque. Usage of one of the three parameters will require approval in advance by the Administrator. The control parameter values that correspond to the appropriate percent loads as specified in the emission test cycle will be initially determined at the zero-hour point or after an appropriate break-in procedure. The control parameter values determined initially will be used for the entire service accumulation schedule. If at any time during the service accumulation, the 90% torque value cannot be attained, the engine shall be operated at wide open throttle.

(iii) The average speed shall be between 1,650 and 1,700 rpm. Subject to the requirements as to average speed, there must be operation at speeds in excess of 3,200 rpm (but not in excess of governed speed for governed engines or rated speed for non-governed engines) for a cumulative maximum of 0.5 percent of the actual cycle time, excluding time in transient conditions. Maximum cycle time shall be 15 minutes. A cycle approved in advance by the Administrator shall be used.

(3) (i) For Diesel engines, the following criteria must be met before service accumulation can begin. Failure to comply with these requirements shall invalidate all test data submitted for an engine.

(A) Each engine shall produce at least 95 percent of the maximum horsepower, corrected to rating conditions, at 95 to 100 percent of the rated speed.

(B) The fuel rate at maximum horsepower shall be within manufacturer's specifications.

(ii) During service accumulation, hours can be credited toward the required service accumulation hours when the following criteria are met. If these criteria cannot be met, engine operation shall be discontinued and the Administrator shall be notified immediately. (Adjustments to the fuel rate can be approved under the provisions of § 86.079–25.)

(A) Each engine shall produce at least 95 percent of the maximum horsepower, at 95 to 100 percent of the rated speed, observed at the zero-hour point. Horsepower values shall be corrected to the rating conditions.

(B) The engine shall be operated at 75 percent of the inlet and exhaust restrictions specified in § 86.879–8 except that the tolerance will be ±3 inches of water and ±0.5 inches of Hg respectively.

(C) During each emission test the inlet and exhaust restrictions shall be specified in § 86.879–8.

(4) If a break-in procedure is used the procedure must be the same as recommended to the ultimate purchaser. Prior approval by the Administrator is required for use of any break-in procedure. The hours accumulated during the break-in procedure will not be counted as part of the service accumulation.

(5) Emission data engines: Each emission data engine shall be operated for 125 hours with all emission control systems installed and operating. An emission test shall be conducted at 125 hours. No zero hour emission test will be required or allowed. Evaporative emission controls need not be connected provided normal operating conditions are maintained in the engine induction system.

(6) Durability data engines: Each gasoline-fuel durability data engine shall be operated, with all emission control systems installed and operating, for 1,500 hours. Each Diesel durabiilty data engine shall be operated, with all emission control systems installed and operating, for 1000 hours. Emission measurement, as prescribed, shall be made at 125 intervals beginning at 125 hours of operation. No zero hour emission test will be required or allowed. Evaporative emission controls need not be connected provided normal operating conditions are maintained in the induction systems.

(7) All tests required by this subpart to be conducted after 125 hours of operation or at any multiple of 125 hours may be conducted at any accumulated number of hours within 8 hours of 125 hours or the appropriate multiple of 125 hours, respectively.

(8) (i) Data from all emission tests (including voided tests) shall be air posted to the Administrator within 72 hours (or delivered within five working days). The manufacturer shall furnish to the Administrator an explanation for voiding any test. The Administrator will determine if voiding the test was appropriate based upon the explanation given by the manufacturer for the voided test. If a manufacturer conducts multiple tests at any test point at which the data are intended to be used in the calculation of

the deterioration factor, the number of tests must be the same at each point and may not exceed three valid tests. Tests between test points may be conducted as required by the Administrator. In addition, all test data shall be compiled and provided to the Administrator in accordance with § 86.079–23. Where the Administrator conducts a test on a durability engine at a prescribed test point, the results of that test will be used in the calculation of the deterioration factor.

(ii) The results of all emission tests shall be recorded and reported to the Administrator using two places to the right of the decimal point. These numbers shall be rounded in accordance with the "Rounding Off Method" specified in ASTM E 29–67.

(9) Whenever the manufacturer proposes to operate and test an engine which may be used for emission or durability data, he shall provide such information concerning components used on the engine as the Administrator may require and make the engine available for such testing under § 86.077–29 as the Administrator may require, before beginning to accumulate hours on the engine. Failure to comply with this requirement will invalidate all test data later submitted for this engine.

(10) Once a manufacturer begins to operate an emission data or durability data engine, as indicated by compliance with paragraph (b)(9) of this section, he shall continue to run any emission data engine to 125 hours, any gasoline-fueled durability data engine to 1,500 hours, and any Diesel durability data engine to 1000 hours. The data from the engine will be used in the calculations under § 86.345. Discontinuation of a engine shall be allowed only with the prior written consent of the Administrator.

(11)(i) The Administrator may elect to operate and test any test engine during all or any part of the service accumulation and testing procedure. In such cases the manufacturer shall provide the engine(s) to the Administrator with all information necessary to conduct the testing.

(ii) The test procedures (subpart D for gasoline-fueled engines, and subparts D and I for Diesel engines) will be followed by the Administrator. The Administrator will test the engines at each test point. Maintenance may be performed by the manufacturer under such conditions as the Administrator may prescribe.

(iii) The data developed by the Administrator for the engine-system combination shall be combined with any applicable data supplied by the manufacturer on other engines of that combination to determine the applicable deterioration factors for the combination. In the case of a significant discrepancy between data developed by the Administrator and that submitted by the manufacturer, the Administrator's data shall be used in the determination of deterioration factors.

(12) Emission testing of any type with respect to any ceritfication engine other than that specified in this subpart is not allowed except as such testing may be specifically authorized by the Administrator.

8. A new section § 86.079–27 is added and reads as follows:

§ 86.079–27 Special test procedures.

(a) For light duty vehicles and light duty trucks the Administrator may, on the basis of a written application therefore by a manufacturer, prescribe test procedures, other than those set forth in this part, for any motor vehicle which he determines is not susceptible to satisfactory testing by the procedures set forth herein or in subpart B.

(b) For heavy duty engines:

(i) The Administrator, may on the basis of a written application therefore by a manufacturer, prescribe test procedures, other than those set forth in this subpart, for any motor vehicle engine which he determines is not susceptible to satisfactory testing by the procedures set forth herein or in subparts D and I.

(ii) If the manufacturer does not submit a written application for use of special test procedures but the Administrator determines that a motor vehicle engine is not susceptible to satisfactory testing by the procedures set forth herein, the Administrator will reject the applicable portions of the application. The Administrator shall notify the manufacturer in writing and set forth the reasons for such rejection in accordance with the provisions of § 86.077–22(c).

9. A new section 86.079–28 is added and reads as follows:

§ 86.079–28 Compliance with emission standards.

(a) [See paragraph (a) of § 86.077–28]

(b)(1) Paragraph (b) of this section applies to heavy duty engines.

(2) The exhaust emission standards for gasoline-fueled engines in § 86.079–10 or for Diesel engines in § 86.079–11 apply to the emissions of engines for their useful life.

(3) Since emission control efficiency decreases with the accumulation of hours on the engine, the emission level of a gasoline-fueled engine which has accumulated 1,500 hours of dynamometer operation or a Diesel engine which has accumulated 1000 hours of dynamometer operation will be used as the basis for determining compliance with the standards.

(4) The procedure for determining compliance of a new engine with exhaust emission standards is as follows:

(i) Separate emission deterioration factors shall be determined from the emission results of the durability data engines for each engine-system combination. Separate factors shall be established for HC, CO, and for the combined emissions of HC and NOx. For Diesel engines, separate factors shall also be established for the acceleration mode (designated as "A"), the lugging mode (designated as "B") and the peak opacity (designated as "C").

(A) The applicable results to be used in determining the deterioration factors for each combination shall be:

(*1*) All emission data from the tests required under § 86.079–26(b)(6). This shall include the official test results, as determined in § 86.077–29, for all tests conducted on all gasoline-fueled durability engines of the combination selected under § 86.079–24(c)(2) or on all Diesel durability engines of the combination selected under § 86.079–24(c)(3) (including all engines elected to be operated by the manufacturer under § 86.079–24(c)(2)(iii) for gasoline-fueled engines or under § 86.079–24(c)(3)(ii) for Diesel engines).

(*2*) All emission data from the test conducted before and after maintenance provided in § 86.079–25(c)(2)(i)(A) for gasoline fueled engines or in § 86.079–25(c)(2)(i)(B) for Diesel engines.

(*3*) All emission data from the tests conducted before and after maintenance provided in § 86.079–25(c)(5)(i) if emission tests were conducted.

(B) All applicable emission results for (*1*), HC, (*2*) CO, (*3*) HC+NOx, (*4*) acceleration smoke ("a"), (*5*) lugging smoke ("b"), and (*6*) peak smoke ("c") shall be plotted as a function of durability hours which shall be consistently rounded to the nearest hour. Emission data shall have two figures to the right of the decimal. The best fit straight lines, fitted by the method of least squares, shall be drawn through these data points. The interpolated 125-hour and 1500-hour points for gasoline-fueled engines or the 1000-hour points for Diesel engines on each line, rounded to whole numbers in accordance with ASTM E 29–67, must be within the standards specified in § 86.077–10 for gasoline-fueled engines or in § 86.077–11 for Diesel engines or the data shall not be used in the calculation of the deterioration factor, unless no applicable data points exceed the standards.

(C) The interpolated values shall be used to calculate a deterioration factor as follows:

Factor = Exhaust emissions interpolated to 1500 hours for gasoline-fueled engines or to 1000 hours for Diesel engines minus the exhaust emissions interpolated to 125 hours. (Negative deterioration factors shall be considered zero.)

(ii) The appropriate deterioration factor, carried out to two places to the right of the decimal point, shall be added to the exhaust emission test results, carried out to two places to the right of the decimal point, for each emission data engine.

(iii) The emission values to compare with the standards shall be the adjusted emission values of paragraph (b)(4)(ii) of this section rounded to whole numbers in accordance with ASTM E 29–67 for each emission data engines.

(iv) Every test engine of an engine family must comply with all applicable standards, as determined in paragraph (b)(4)(iii) of this section, before any engine in that family will be certified.

10. A new section 86.079–35 is added and reads as follows:

§ 86.079–35 Labeling.

(a)(1) [See paragraph (a)(1) of §86.-077–35]

(2) Heavy duty engines:

(i) The plastic or metal label shall be welded, bonded, or otherwise permanently attached to the engine in a position in which it will be readily visible after installation in the vehicle.

(ii) The label shall be attached to an engine part necessary for normal engine operation and not normally requiring replacement during engine life.

(iii) The label shall contain the following information letterd in the English language in block letters and numerals which shall be of a color that contrasts with the background of the label:

(A) The label heading: Engine Exhaust Emission Control Information;

(B) Full corporate name and trademark of manufacturer;

(C) Engine displacement (in cubic inches) and engine family and model designations;

(D) Date of engine manufacture (month and year);

(E) Engine specifications and adjustments as recommended by the manufacturer. These specifications should indicate the proper transmission position during tuneup and what accesories (e.g., air conditioner), if any, should be in operation;

(*f*) For gasoline-fueled engines the label should include the idle speed, ignition timing, and the idle air-fuel mixture setting procedure and value (e.g., idle CO, idle air-fuel ratio, idle speed drop) and valve lash.

(2) For Diesel engines the label should include the advertised hp. at rpm, fuel rate at advertised hp. in m.m.^{3}/stroke, valve lash, initial injection timing, and idle speed.

(F) An unconditional statement of compliance with the appropriate model year (e.g., 1979) U.S. Environmental Protection Agency regulations applicable to heavy duty engines.

(iv) The label may be made up of one or more pieces provided that all pieces are permanently attached to the same engine or vehicle part as applicable.

(b) [See paragraph (b) of § 86.077–35]

11. A new subpart D is added to Part 86 and reads as follows:

Subpart D—Emission Regulations for New Gasoline—Fueled and Diesel Heavy Duty Engines; Gaseous Exhaust Test Procedure

Sec.

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86.305–79 Introduction, structure of subpart.
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86.310–79 Sampling and analytical system; component specifications.
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86.318–79 Oxides of nitrogen analyzer specifications.
86.319–79 Analyzer checks and calibrations, frequency and overview.
86.320–79 Analyzer bench checks.
86.321–86.325 [Reserved]
86.326–79 Non-linearity check, CO and CO_2 analyzers.
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86.341–79 Diesel engine dynamometer test run.
86.342–79 Post-test procedure.
86.343–79 Chart reading.
86.344–79 Humidity calculations.
86.345–79 Emission calculations.

AUTHORITY: Secs. 202, 206, 207, 208, 301(a) of the Clean Air Act, as amended (42 U.S.C. 1857f–1, 1857f–5, 1857f–5a, 1857f–6, 1857g(a)).

Subpart D—Emission Regulations for New Gasoline-fueled and Diesel Heavy Duty Engines; Gaseous Exhaust Test Procedures

§ 86.301–79 Scope, applicability.

This subpart contains gaseous emission test procedures for gasoline-fueled and Diesel heavy duty engines. It applies to 1979 and later model years.

§ 86.302–79 Definitions.

The definition in § 86.077–2 and § 86.079–2 apply to this subpart.

§ 86.303–79 Abbreviations.

The abbreviations in § 86.079–3 apply to this subpart.

§ 86.304–79 Section numbering, construction.

(a) The model year of initial applicability is indicated by the section number. The two digits following the hyphen designate the first model year for which a section is effective. A section remains effective until superseded.

EXAMPLE: Section § 86.311–79 applies to the 1979 and subsequent model years until superseded. If a section § 86.311–81 is promulgated it would take effect beginning with the 1981 model year; § 86.311–79 would apply to model years 1979 and 1980.

(b) A section reference without a model year suffix refers to the section applicable for the appropriate model year.

(c) Unless indicated, all provisions in this subpart apply to both gasoline-fueled and Diesel heavy duty engines.

§ 86.305–79 Introduction, structure of subpart.

(a) This subpart describes the equipment required and the procedures to follow in order to perform exhaust emission tests on gasoline-fueled and Diesel heavy duty engines. Subpart A sets forth the testing requirements and test intervals necessary to comply with EPA certification procedures.

(b) Four topics are addressed in this subpart. Sections §§ 86.306 through 86.318 set forth specifications and equipment requirements; §§ 86.319 through 86.333 discuss calibration methods and frequency; test procedures and data requirements are listed (in approximately chronological order) in §§ 86.334 through 86.343, and calculation formulas are found in §§ 86.344 and 86.345.

§ 86.306–79 Equipment required and specifications, overview.

(a) This subpart contains procedures for both gasoline-fueled and Diesel engine gaseous emission tests. Generally, the equipment required is identical for both types of engines. Equipment required and specifications are found in §§ 86.307 through 86.318.

(b) Some analyzer specifications refer to calibration checks found in §§ 86.320 through 86.332.

§ 86.307–79 Fuel specifications.

(a) *Gasoline.* (1) Gasoline having the following specifications will be used by the Administrator in exhaust emission testing. Gasoline having the following specifications or substantially equivalent specifications approved by the Administrator, shall be used by the manufacturer in exhaust testing, except that the lead and octane specifications do not apply.

Item designation	ASTM	Leaded	Unleaded
Octane, research, minimum.	D1656	100	96
Pb (organic), grams per U.S. gallon.	.....	[1] 1.4	0.00–0.05
Distillation range:			
IBP, °F	D86	75–95	75–95
10-pct point, °F	D86	120–135	120–135
50-pct point, °F	D86	200–230	200–230
90-pct point, °F	D86	300–325	300–325
EP, °F (maximum).	D86	415	415
Sulfur, weight percent, maximum.	D1266	0.10	0.10
Phosphorus, grams per U.S. gallon, maximum.	.....	.01	.005
RVP, pounds	D323	8.0–9.2	8.0–9.2
Hydrocarbon composition:			
Olefins, percent, maximum.	D1319	10	10
Aromatics, percent, maximum.	D1319	35	35
Saturates	D1319	Remainder	Remainder

[1] Minimum.

(2) Gasoline representative of commercial gasoline which will be generally available through retail outlets shall be used in service accumulation. For leaded gasoline, the minimum lead content shall be 1.4 grams per U.S. gallon, except that where the Administrator determines that engines represented by the test engine

will be operated using gasoline of different lead content than that prescribed in this paragraph, he may consent in writing to use of a gasoline with a different lead content. The octane rating of the gasoline used shall be no higher than 4.0 research octane numbers above the minimum recommended by the manufacturer and have a minimum sensitivity of 8.0 octane numbers, where sensitivity is defined as research octane number minus motor octane number.

(b) *Diesel fuel.* (1) The Diesel fuels employed for testing shall be clean and bright, with pour and cloud points adequate for operability. The Diesel fuel may contain nonmetallic additives as follows: Cetane improver, metal deactivator, antioxidant, dehazer, antirust, pour depressant, dye, and dispersant.

(2) Diesel fuel meeting the following specifications, or substantially equivalent specifications approved by the Administrator, shall be used in exhaust emissions testing. The grade of Diesel fuel recommended by the engine manufacturer commercially designated as "Type 1–D" or "Type–2D", shall be used.

Item	ASTM test method No.	Type 1–D	Type 2–D
Cetane	D613	48–54	42–50
Distillation range	D86		
IBP, °F		330–390	340–400
10-pct point, °F		370–430	400–460
50-pct point, °F		410–480	470–540
90-pct point, °F		460–520	550–610
EP, °F		500–560	580–660
Gravity, °API	D287	40–44	33–37
Total sulfur, percent	D129 or D2622	0.05–0.20	0.2–0.5
Hydrocarbon composition.	D1319		
Aromatics, percent.		[1] 8	[1] 27
Paraffins, naphthenes, olefins.		Remainder	Remainder
Flashpoint °F. (minimum).	D93	120	130
Viscosity, centistokes.	D445	1.6–2.0	2.0–3.2

[1] Minimum.

(3) Diesel fuel meeting the following specifications, or substantially equivalent specifications approved by the Administrator, shall be used in service accumulation. The grade of Diesel fuel recommended by the engine manufacturer, commercially designated as "Type 1–D" or "Type 2–D", shall be used.

Item	ASTM test method No.	Type 1–D	Type 2–D
Cetane (min.)	D613	42–56	38–58
Distillation range 90-pct point, °F.	D86	440–530	540–630
Gravity °API	D237	39–45	30–42
Total sulfur, percent	D129 or D2622.	[1] 0.05	[1] 0.2
Flash point, °F (min.)	D93	120	130
Viscosity, centistokes	D445	1.2–2.2	1.5–4.5

[1] Minimum.

(4) Other petroleum distillate fuels may be used for testing and service accumulation provided:

(i) They are commercially available, and

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service, and

(iii) Use of a fuel listed under paragraphs (b)(2) and (b)(3) of this section would have a detrimental effect on emissions or durability, and

(iv) Written approval from the Administrator of the fuel specifications was provided prior to the start of testing.

(5) The specification range of the fuels to be used under subparagraphs (b)(2), (b)(3), and (b)(4) of this section shall be reported in accordance with § 86.077–21(b)(3).

§ 86.308–79 Gas specifications.

(a) *Analyzer gases:* (1) Calibration or span gases for the CO and CO_2 analyzers shall have zero-grade nitrogen as a diluent.

(2) Calibration or span gases for the hydrocarbon analyzer shall be propane with zero-grade nitrogen as a diluent when testing gasoline-fueled engines. For Diesel engine tests the diluent shall be zero-grade air.

(3) Calibration or span gases for the NOx analyzer shall be single blends of NO named as NOx with a maximum NO_2 concentration of 5 percent of the nominal value. Zero-grade nitrogen shall be the diluent.

(4) Zero gases for hydrocarbon analyzers shall be nitrogen when testing gasoline fueled engines and air when testing Diesel engines.

(5) Zero gases for the carbon monoxide, carbon dioxide and oxides of nitrogen analyzers shall be either zero grade air or zero grade nitrogen.

(6) The allowable zero grade gas (air or nitrogen) impurity concentrations shall not exceed 2 ppm C hydrocarbon, 10 ppm carbon monoxide, 400 ppm carbon dioxide and 1 ppm nitric oxide.

(7) "Zero grade air" includes artificial air consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(b) *Calibration gas:* Calibration gas concentrations shall be traceable within 1 percent of applicable National Bureau of Standards gas blends concentrations. Alternatively, calibration gas concentrations shall be named with a 99% confidence level within 2% of true concentration.

(c) *Span gas:* Span gas concentrations shall be traceable to within 1 percent of a calibration gas.

(d) *Hydrocarbon analyzer fuel:* (1) The fuel shall contain 40±1% hydrogen. The balance shall be helium. The mixture shall contain less than 2 ppm C hydrocarbon.

(2) Alternate pure hydrogen fuel: Some FIDs are designed to operate on pure hydrogen. Generally this FID fuel is incompatible with good relative hydrocarbon response.

(i) For Diesel engines this fuel is not recommended. However, this fuel may be used if the engine manufacturer demonstrates, across his product line, that a FID using this fuel produces comparable results to a FID using 40% H_2/60% He fuel. These data must be submitted to and approved by the Administrator prior to testing. Pure H_2 fuel, that may be allowed for testing, must contain at least 99.0 percent hydrogen and contain less than 2 ppm C hydrocarbon.

(ii) For gasoline-fueled engines, pure hydrogen fuel for the FID is not allowed.

(e) *Hydrocarbon analyzer burner air:* The burner air should contain nominally 21±1 percent oxygen. The concentration of oxygen must be within 1 mole percent of the oxygen concentration of the burner air used in the latest oxygen interference check ($\%O_2I$). If the difference in oxygen concentration is greater than 1 mole percent, then the oxygen interference must be checked and the analyzer adjusted, if necessary, to meet the $\%O_2I$ requirements. The burner air must contain less than 2 ppm C hydrocarbon.

(f) Oxygen interference check gases shall contain propane with a 350 ppm C±50 ppm C concentration named by chromatographic analysis to calibration gas tolerances. Nitrogen shall be the predominant diluent with the balance oxygen. Blends required for gasoline-fueled and Diesel engine testing are as follows:

Applicability	O_2 concentration (percent)	Balance
Diesel	21 (20–22)	N_2
Do	15 (14–16)	N_2
Diesel and gasoline	10 (9–11)	N_2
Do	5 (4–6)	N_2
Gasoline	0 (0–1)	N_2

§ 86.309–79 Sampling and analytical system; schematic.

(a) Schematic drawing. (1) Fig. D79–1 is a schematic drawing of the exhaust gas sampling and analytical system which shall be used for testing under this subpart. All components or parts of components that are wetted by the sample or corrosive calibration gases are to be either chemically cleaned stainless steel or inert material, e.g. polytetrafluroethylene resin. The use of "gauge savers" or "protectors" with nonreactive diaphragms is permissible.

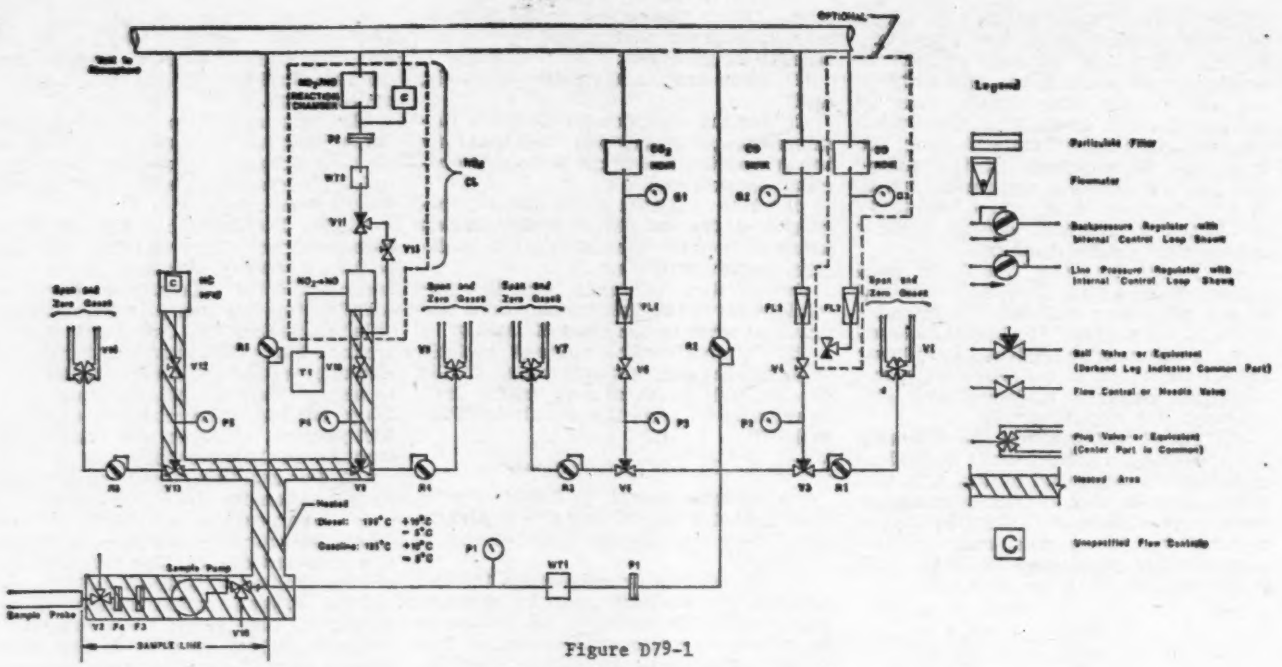

Figure D79-1

Heavy Duty Exhaust Gas
Sampling and Analytical Train

(2) Any variations from the depicted system, including instrument detection method or internal instrument flow controls, may be used only with prior approval from the Administrator based on proven equivalency.

(b) *System Components List.* The following is a list of components shown in Fig. D79-1 by numeric identifier. Pressure ranges and accuracies when given are suggested values. Deviations from suggested values do not require prior approval.

(1) *Filters:* It is suggested that for F1, F2, and F3, a 7 cm diameter glass fiber filter paper be used. Optional filter F4 is a coarse filter for large particulates.

(i) F1—Fine particulate filter.

(ii) F2—Fine particulate filter.

(iii) F3—Fine heated particulate filter.

(iv) F4—Coarse heated particulate filter (optional).

(2) *Flowmeters:* Flowmeters FL 1 and FL 2 indicate sample flow rates through the CO and CO_2 analyzers, (0–10 CFH).

(3) *Gauges:* Gauges G1 and G2 measure input pressure to CO and CO_2 detector cells (0–15" H_2O gauge). These gauges measure pressure drop across the detector cell.

(4) *Pressure gauges:* (i) P1—bypass pressure (0–20 psig).

(ii) P2, P3, P4 and P5—sample or span pressure at inlet to flow control valves (0–10 psig).

(5) *Water traps:* Water traps WT1, and WT2 are to remove water from the sample. Chemical dryers are not an acceptable method of removing the water. Water removal by condensation is acceptable. Means other than condensation may be used only with prior approval from the Administrator based on proven equivalency.

(6) *Regulators:* (i) R1, R3, R4, and R6—line pressure regulators to control span pressure at inlet to flow control valves (0–10 psig, sensitivity ±2" H_2O).

(ii) R2 and R5—back pressure regulators to control sample pressure at inlet to flow control valves (0–10 psig, sensitivity ±2" H_2O).

(7) *Valves:* (i) V1, V7, V8, and V14—selector valves to select zero- or calibration-gases.

(ii) V2—optional heated selector valve to purge the sample probe, perform leak checks, or to perform hang-up checks.

(iii) V3 and V5—selector valves to select sample or span gases.

(iv) V4, V6, and V15—flow control valves.

(v) V9 and V13—heated selector valve to select sample or span gases.

(vi) V10 and V12—heated flow control valves.

(vii) V11—selector valve to select NOx or bypass mode in the chemiluminescence analyzer.

(viii) V16—optional heated selector valve to perform leak checks.

(8) *Pump:* Sample transfer pump to transport sample to analyzers (1.0 CFM at 10 psig).

(9) *Temperature sensor:* T1 measures the NO_2 to NO reduction converter temperature (0–1000°C, 32–1832°F.)

§ 86.310–79 Sampling and analytical system; component specifications.

(a) *Temperature.* Any heated component must be maintained at: (1) 125°C; +10°C, −5°C (257°F; +18°F, −9°F) for gasoline-fueled engines.

(2) 190°C; +10°C, −5°C, (374°F; +18°F. −9°F) for Diesel engines.

(b) *Sample probe.* (1) The sample probe shall be a straight, closed end, stainless steel, multi-hole probe. The I.D. shall be between 0.18 and 0.32 inches.

(2) There shall be a minimum of three holes in the probe. The spacing of the radial planes for each hole in the probe must be such that they cover approximately equal cross-sectional areas of the exhaust duct. The angular spacing of the holes must be approximately equal. The angular spacing of any two holes in one plane may not be 180°±20°. The holes should be sized such that each has approximately the same flow. See Figure D79-2.

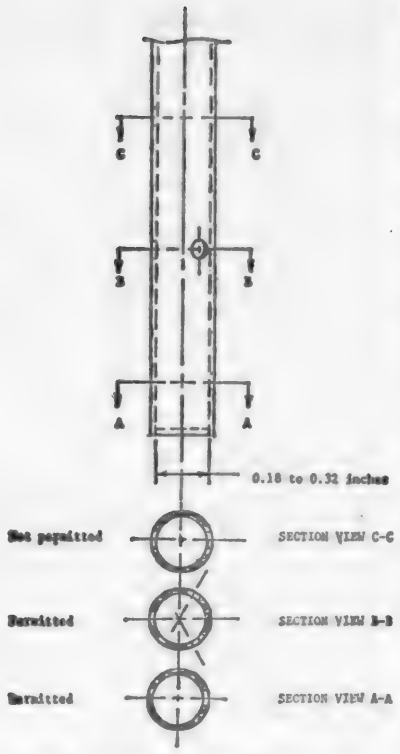

Figure D79-2 SAMPLE PROBE AND TYPICAL HOLE SPACINGS

(3) The probe shall extend radially across the exhaust duct. The probe must pass through the approximate center and must extend across at least 80 percent of the diameter of the duct.

(c) (1) *Sample transfer:* The exhaust gas sample shall be transferred to the analytical instruments through a heated filter and heated line by a heated sample pump.

(2) All heated lines shall be of chemically cleaned stainless steel construction.

(3) The I.D. of the sample line shall be between 0.18 and 0.32 inches.

(4) Generally, the sample-line length should be limited to 50 feet. Longer sample-line may be used if the total system response time and the hydrocarbon hang-up check meet the requirements for testing under this subpart.

(5) The sample line outside wall temperature must be maintained at the temperature specified in paragraph (a) of the section. An exception is made for the first two feet of sample-line from the exhaust duct. The upper temperature tolerance for this two foot section will be increased to +60°C (+108°F).

(6) The sample pump should be located as close as practical to the sample probe, and the wetted surfaces of the pump must be heated.

(7) If valve V2 is used, the sample probe must connect directly to valve V2. The location of optional valve V2 may not be greater than two feet from the exhaust duct.

(8) The location of optional valve V16 may not be greater than 12 inches from the sample pump. The leakage rate for this section on the pressure side of the sample pump may not exceed the leakage rate on the vacuum side of the pump.

(d) Venting. (1) The method of disposing of the sample is not specified. However, caution must be used in routing of the vent lines.

(2) Venting of the instruments, especially the NDIR analyzers, must be such that the analyzer vent does not see a back pressure caused by the proximity of other vents.

(3) Pressure relief vents of regulators should be vented to the atmospheric vent manifold for safety.

§ 86.311–79 Miscellaneous equipment, specifications.

(a) *Chart recorders.* (1) the minimum chart speed allowed is 3 inches per minute for gasoline-fueled engines and 0.5 inches per minute for Diesel engines.

(2) When testing gasoline-fueled engines all chart recorders (analyzers, torque, rpm, etc.) shall be provided with automatic markers which indicate one second intervals. Preprinted chart paper (one second intervals) may be used in lieu of the automatic markers provided the correct chart speed is used.

(b) All temperature measurements, (wet, bulb, dry bulb, dew point, etc.) shall be accurate to within ±0.5°C.

(c) *Intake air humidity and temperature measurements.* (1) Humidity conditioned air. Air that has had its absolute humidity altered is considered humidity conditioned air. For this type of intake air, the humidity measurement must be made within the intake air system, and after the air conditioning has taken place. Also, this measurement must be made within 48 inches of the engine.

(2) Non-conditioned air. Humidity measurements in non-conditioned intake air systems must be made in the intake air stream and within 18 inches of the inlet for engine intake air system.

(3) Intake air temperature measurement must be made in the intake air stream and within 48 inches of the engine.

(4) Temperature and humidity devices must have a time constant, τ, between 13 and 52 seconds. For a given instantaneous step change the measurement system must respond to 63.2% of that step change. If the temperature and humidity measurement systems have a time constant τ, less than 13 seconds, then the measurements will be sampled at a rate four or more times faster than the time constant τ and averaged. For continuously integrated intake air temperature systems, excursions exceeding the temperature limits for 30 seconds or less will be allowed.

(d) Dynamometer room temperature must be measured in two locations in the room within 10 feet of the engine. The two measurements are averaged. The measurement system must have a time constant, τ, between 13 and 52 seconds. For a given instantaneous step change the measurement system must respond to 63.2% of that step change. If the temperature measurement system has a time constant τ, less than 13 seconds, then the measurements will be sampled at a rate four or more times faster than the time constant τ and averaged. For continuously integrated dynamometer room air temperature systems, excursions exceeding the temperature limits for 30 seconds or less will be allowed.

(e) Sample component surface temperatures. (1) Measure the sample pump surface temperature.

(2) Measure the surface temperature of all heated filters.

(3) For each section of sample-line 10 feet long or less, that has a separate source of power of heating element, measure the sample wall line temperature at least at one location.

(4) For each section of sample-line longer than 10 feet that has a separate source of power or heating element, measure the sample line wall temperature at least at two locations. These sensor locations must be approximately equal distance from each other and the ends of the sample-line.

(f) If water is removed by condensation the exit gas temperature must be measured and may not exceed 7°C (45°F).

§ 86.312–79 Dynamometer and engine equipment specifications.

(a) *Dynamometer.* (1) The dynamometer test stand and other instruments for measurement of power output shall be accurate to within 2 percent of point at all power settings. The dynamometer must be capable of performing the test cycle, § 86.335 or § 86.336. Dynamometers used for testing gasoline-fueled engines must have motoring capability.

(2) Dynamometer calibration weights. A minimum of 6 calibration weights for each range used are required. The weights must be equally spaced and traceable to within 1% of NBS weights.

(b) *Engine cooling.* Means of engine cooling which will maintain the engine operating temperatures at approximately the same temperature as specified by the manufacturer shall be used. An auxiliary fixed speed fan may be used to maintain engine cooling during sustained operation on the dynamometer.

(c) *Exhaust system.* (1) A chassis-type single pipe exhaust system shall be used. Standard or specially fabricated "Y" pipes may be used for Vee type engines. The probe shall be located three to ten feet downstream from the exhaust manifold outlet flange, turbocharger exit flange or emission control device(s) (catalyst, etc.).

Further, the probe location must be at least three feet downstream of any "Y" intersection. If a catalyst(s) is used, the catalyst(s) must be located the same distance from the exhaust manifold flange as in the vehicle configuration. For Vee Type engines the "Y" intersection must be downstream of the catalyst(s).

(2) When testing Diesel engines a noninsulated exhaust system extending 15±5 feet from the exhaust manifold,

or the crossover junction in the case of Vee engines, and presenting an exhaust back pressure within ±0.2 inch Hg. of the upper limit at maximum rated horsepower, as established by the engine manufacturer in his sales and service literature for vehicle application, shall be used. A conventional automotive muffler of a size and type commonly used with the engine being tested shall be employed in the exhaust system during smoke emission testing. The terminal 2 feet of the exhaust pipe shall be circular cross section and be free of elbows and bends. The end of the pipe shall be cut off squarely. The terminal 2 feet of the exhaust pipe shall have a diameter in accordance with the engine being tested, as specified below:

Maximum rated horsepower:	*Exhaust pipe diameter (inches)*
Less than 101	2
101–200	3
201–300	4
301 or more	5

§ 86.313–79 Air flow measurement specifications.

(a) The air flow measurement method used must have a turn-down ratio large enough to accurately measure the airflow over the engine operating range during the test. Overall measurement accuracy must be ±1 percent of full-scale value of the measurement device. The Administrator must be advised of the method used.

(b) Corrections to the measured air mass-flow-rate: When an engine system incorporates devices that add or subtract air mass (air injection, bleed air, etc.), determine the air mass from these devices by one of the following methods:

(1) Measure the air mass-flow from the device during each operating mode by a method approved by the Administrator.

(2) Demonstrate to the Administrator that the air mass-flow for each mode from the device is typical for many system applications. Then the device flow-rate for each mode may be generally applied.

(3) Under certain circumstances, the Administrator will accept theoretical calculations that predict the device mass flow-rate during each mode.

(c) Gasoline-fueled engine systems: (1) Flow distribution: The air cleaner is considered part of the engine system. A plenum chamber of sufficient volume is recommended to insure uniform distribution to the engine.

(2) Velocity profile: The velocity profile is considered the velocity profile to the air cleaner. The desired condition is a uniform velocity profile with a velocity between 3.3 to 13.2 meters per second (10 to 40 feet per second) delivering air to the air cleaner.

(3) Pressure drop: The pressure drop (from atmospheric pressure) at the inlet to the air cleaner must not be more than 1.74 kPa (7.0 in H_2O).

(4) Vents: Devices like PCV valves that vent to the air cleaner, must continue to be vented to the air cleaner. Devices that vent to the atmosphere as some carburetor float vents, governors, etc. must vent to the plenum chamber.

(5) Hot air: (i) Ducted Ambient Air: On engines that use ducted ambient air to the carburetor, the hot air device will be non-functional during the test sequence. The engine will induct ambient air at 20°C (68°F) to 30°C (86°F).

(ii) Under-Hood Air: On engines that induct air under the hood, the hot air device (if used) will be non-functional during the test sequence. The engine will induct air at a typical under hood temperature that would occur on a 20°C (68°F) to 30°C (86°F) day. The manufacturer will specify and substantiate the under-hood intake air temperature.

(d) Diesel engine systems. An engine air inlet system presenting an air inlet restriction within ±1 inch of water of the upper limit for the engine operating condition which results in maximum air flow, as established by the engine manufacturer in his sales and service literature, for the Diesel engine being tested shall be used.

§ 86.314–79 Fuel flow measurement specifications.

(a) The fuel flow-rate measurement instrument must have a minimum accuracy of 1 percent of full-scale flow-rate for each measurement range used. The controlling parameters are the elapsed time measurement of the event and the weight or volume measurement. Restrictions on these parameters are:

(1) The error in the elapsed time measurement of the event must not be greater than 1 percent of the absolute event time. This includes errors in starting and stopping the clock as well as the period of the clock.

(2) If the mass of fuel consumed is measured by discrete weights, then the error in the actual weight of the fuel consumed must not be greater than 1 percent of the measuring weight.

(3) If the mass of fuel consumed is measured electronically (load cell, load beam, etc.), the error in the actual weight of fuel consumed must not be greater than 1 percent of the full-scale value of the electronic device.

(4) If the mass of fuel consumed is measured by volume flow and density, the error in the actual volume consumed must not be greater than 1 percent of the full-scale of the volume measuring device.

(b) For devices that have varying mass scales (electronic weight, volume, density, etc.), measurements may not be used for calculations if the measurement is less than twenty percent of full scale.

(c) Option: Complete flow-rate measurement systems may be used below 20 percent of full-scale measurement as long as the combination of mass and time measurements indicate a flow-rate that has an error of less than 5 percent of the actual absolute flow-rate.

§ 86.315–79 General analyzer specifications.

(a) *Analyzer response-time:* The analyzer must respond to an instantaneous step change at the entrance to the analyzer with a response equal to 95 percent of that step change in 3.0 seconds or less on all ranges used.

(b) *Precision:* The precision of the analyzer must be no greater than ±1 percent of full-scale for each range used. The precision is defined as 2.086 times the standard deviation (σ) of 20 repetitive responses to a given calibration gas.

(c) *Noise:* The analyzer peak to peak output noise at frequencies greater than 0.1 hertz must not exceed ±1 percent of full-scale on all ranges used.

(d) *Zero drift:* The analyzer zero-response drift during a 1 hour period shall be less than ±1 percent of full-scale on the lowest range used. The zero-response is defined as the mean response to a zero gas during a 30 second time interval including peak to peak noise at frequencies less than 0.1 hertz.

(e) *Span drift:* The analyzer span drift during a 1 hour period shall be less than ±1 percent of full-scale on the lowest range used. The analyzer span is defined as the difference between the span-response and the zero-response. The span-response is defined as the mean response to a span gas during a 30 second time interval including peak to peak noise at frequencies less than 0.1 hertz.

(f) *Linearity:* HC and NOx analyzers must be linear within 2 percent of full scale for each range used.

§ 86.316–79 Carbon monoxide and carbon dioxide analyzer specifications.

(a) Carbon monoxide and carbon dioxide measurements are to be made with NDIR analyzers.

(b) The degree of nonlinearity shall not exceed 15 percent of full scale for all ranges used. See § 86.328 for measurement procedure.

(c) The use of linearizing circuits is permitted.

(d) Zero suppression: Various techniques of zero suppression may be used to increase readability, but only with prior approval by the Administrator.

(e) If the turn down ratio of the carbon monoxide analyzer is not great enough for the desired application, a combination of two or more separate instruments, two or more separate cells with one amplifier, or a multi-cell analyzer may be used. Accomplish this by adding a selector valve between flowmeter F2 and gauge G2 (see Fig. D79–1). All cell flow paths must be parallel and must have a gauge G2 immediately upstream of all detector cells. Vent all detector cells to atmospheric pressure as shown in Fig D79–1.

* * * * *

(g) If the cells are in series optically as in some dual cell arrangements, the cell not in use must be continuously purged with zero-grade gas when analyzing a sample. Furthermore the purge pressure at G2 must be approximately the same as the sample pressure at G2 although the flow rate may be lower. Other combinations must be approved in advance by the Administrator.

§ 86.317–79 Hydrocarbon analyzer specifications.

(a) Hydrocarbon measurements are to be made with an HFID analyzer.

(b) The analyzer shall be fitted with a constant temperature oven housing the detector and sample handling components. It shall maintain temperature within ±2°C. of the set point. The detector, oven, and sample-handling components within the oven shall be suitable for continuous operation at temperatures to 200°C.

(c) Fuel and burner air shall conform to the specifications in § 86.308.

(d) The percent of oxygen interference must be less than 2%, as specified in § 86.331.

(e) Premixed burner air: (1) For Diesel engines, premixing burner air with the FID fuel is not recommended as a means of improving oxygen interference ($\%O_2I$). However, this procedure may be used if the engine manufacturer demonstrates across his product line that an FID using this procedure produces comparable results to an FID not using this procedure. This data must be submitted to the Administrator for his consideration prior to testing.

(2) For gasoline-fueled engines, premixing burner air with the FID fuel is not allowed.

§ 86.318–79 Oxides of nitrogen analyzer specifications.

(a) Oxides of nitrogen are to be measured with a chemiluminescence analyzer.

(b) The NO_2 to NO converter efficiency shall be at least 90%.

(c) The quench interference must be less than 2% as measured in § 86.327.

§ 86.319–79 Analyzer checks and calibrations; frequency and overview.

(a) Prior to initial use and after major repairs bench check each analyzer, see § 86.320.

(b) At least once every seven days during testing check the NO_x converter efficiency, see § 86.332.

(c) At least once every thirty days during testing perform the following:

(1) Leak check the system, see § 86.328.

(2) Calibrate all analyzers; see § 86.330 through 86.332.

(3) Check sample line residence time, see § 86.329.

(4) Verify that the automatic data collection system (if used) meets the chart reading requirements found in § 86.343.

(5) Check the fuel flow measurement instrument to insure that the specifications in § 86.314 are met.

(d) At least once every 180 days during testing check the dynamometer test stand and power output instrumentation, see § 86.333.

§ 86.320–79 Analyzer bench check.

(a) Prior to initial use and after major repairs verify that each analyzer complies with the following specifications:

(1) Response time, see § 86.315(a)
(2) Precision, see § 86.315(b)
(3) Noise, see § 86.315(c)
(4) Zero drift, see § 86.315(d)
(5) Span drift, see § 86.315(e)

In addition, perform a quench check on NOx analyzers, see § 86.327 and a non-linearity check on CO and CO_2 analyzers, see § 86.326.

(b) Condition all new or replacement $NO_2 \rightarrow$ NO convertors. The conditioning consists of either purging the convertor with air for a minimum of 4 hours or until the convertor efficiency is greater than 90 percent. The convertor must be at operational temperature while purging. Do not use this procedure prior to checking convertor efficiency on in-use convertors.

§§ 86.321 through 86.325 [Reserved]

§ 86.326–79 Non-linearity check, CO and CO_2 analyzers.

(a) For CO and CO_2 analyzers the degree of non-linearity of the detector cell shall be determined from the calibration curves of chart deflection vs. calibration concentration and a straight line from zero through the 100% full-scale value. The linearizing circuit (if equipped) shall not be employed during this check. Use calibration procedure specified in § 86.330. Calculate the degree of non-linearity (NL) for each range and calibration concentration by:

$$\%\,NL = \frac{\text{(Actual Chart Deflection - Linear Chart Deflection)}}{\text{Actual Full-Scale Chart Deflection}} 100$$

§ 86.327–79 Quench check, NO_x analyzer.

(a) Perform the reaction chamber quench check for each model of high vacuum reaction chamber analyzer prior to testing.

(b) Perform the reaction chamber quench check for each new analyzer that has an ambient pressure of "soft vacuum" reaction chamber prior to testing. Additionally, perform this check prior to testing each time an analyzer of this type has had the sample capillary repaired or replaced.

(c) Quench check as follows: (1) Calibrate the NOx analyzer on the lowest anticipated range that may be used for testing.

(2) Introduce a mixture of CO_2 and NOx (diluent N_2) to the CL analyzer. Dynamic blending may be used to provide this mixture. The CO_2 concentration should be approximately equal to the highest concentration experienced during testing. Record the response.

(3) Recheck the calibration. If it has changed more than 0.25 percent of full-scale, recalibrate and repeat the quench check.

(4) Prior to testing, the difference between the calculated NOx response and the response if NOx in the presence of CO_2 (step 2) must not be greater than 2 percent. The calculated NOx response is based on the calibration performed in step (1).

§ 86.328–79 Leak checks.

(a) Vacuum side leak check: (1) With the sample pump operating, cap the probe or sample line at the probe fitting. Valve V2 may be used to meet this requirement.

(2) Measure the flow at the discharge of the pump. Valve V16 may be used to facilitate this check.

(3) If the measured flow exceeds 50 cc/min, repair the system.

(b) Pressure Side leak check: (1) Vent the inlet of the sample pump to atmosphere. Valve V2 may be used to meet this requirement.

(2) Cap the sample-line at the point that the line connects to the analysis train.

(3) Measure the flow at the inlet to the pump. Valve V2 may be used to facilitate this check.

(4) If the measured flow exceeds 500 cc/min, repair the system.

(5) All other pressure fittings may be checked by using the bubble-check method. Fitting leakage shall be corrected.

§ 86.329–79 Sample line residence time, check procedure.

(a) Check the sample-line residence time by the following procedure:

(1) Heat the sample-line, sample pump and heated filters to the operating temperature.

(2) Introduce HC span gases into the sampling system at the sample probe or valve V2 at atmosphere pressure. Simultaneously, start the time measurement.

(3) When the HC instrument response is 95 percent of the span gas concentration used, stop the time measurement.

(4) If the elapsed time is more than 15.0 seconds, make necessary adjustments.

(5) Repeat with the CO, CO_2, and NOx instruments and span gases.

§ 86.330–79 Carbon monoxide and carbon dioxide analyzer calibration.

(a) Detector optimization: If necessary, follow the manufacturer's instructions for initial start-up and basic operating adjustments.

(b) Calibration Curve. Develop a calibration curve for each range used: (1) Zero the analyzer.

(2) Span the analyzer to give a response of approximately 90 percent of full-scale chart deflection.

(3) Recheck the zero response. If it has changed more than 0.25 percent of full-scale, repeat steps (1) and (2).

(4) Record the response of calibration gases having nominal concentrations of 15, 30, 45, 60, 75, and 90 percent of full scale concentration.

(5) Generate a rational polynominal calibration curve. The polynomial shall be of fourth order or less and have five or fewer coefficients. Include zero as a data point. The calibration curve must fit the data points within 2 percent of point or 1 percent of full-scale whichever is less.

(c) If any range is within 2% of being linear, a linear calibration may be used. To determine if this criteria is met:

(1) Perform a linear least square regression on the data generated. Use an equation of the form $y=mx$, where x is the actual chart deflection and y is the concentration.

(2) Use the equation $z=y/m$ to find the linear chart deflection (z) for each calibration gas concentration (y).

(3) Determine the linearity (%L) for each calibration gas by:

$$\%L=\frac{(Z-X)}{\text{Full-Scale Linear Chart Deflection}}(100)$$

(4) The linearity criteria is met if the %L is less than ± 2 percent for any data point generated. For each emission test, a calibration curve of the form $y=mx$ is to be used. The slope (m) is defined for each range by the spanning process.

§ 86.331–79 Hydrocarbon analyzer calibration.

The following steps are followed in sequence to calibrate the hydrocarbon analyzer. It is suggested, but not required that efforts be made to minimize relative response variations.

(a) If necessary, follow manufacturer's instructions for instrument start-up and basic operating adjustments.

(b) Set the oven temperature 5° C hotter than the required sample-line temperature. Allow at least one-half hour after the oven has reached temperature for the system to equilibrate.

(c) Adjust fuel flow. With the fuel and air flow rates set at the manufacturer's recommendations, introduce a 350 ppm C±50 ppm C span gas to the detector. Determine the response at a given fuel flow from the difference between the span-gas response and the zero-gas response. Incrementally adjust the fuel flow above and below the manufacturer's specification. Record the span and zero response at these fuel flows. A plot of the difference between the span and zero response versus fuel flow will be similar to the one shown in Fig. D79–3. Adjust the fuel flow rate to the rich side of the curve, as shown. This is initial flow rate setting and may not be the final optimized flow rate.

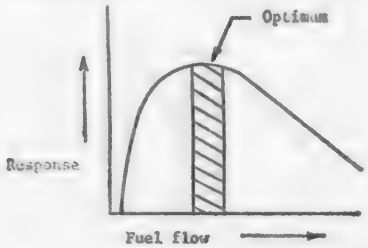

Figure D79-3 RESPONSE vs. FUEL FLOW

(d) Oxygen interference optimization. Choose a range where the 350 ppm C±50 ppm C oxygen interference check gases will fall in the upper 30%. Conduct this test with the oven temperature set as required. Oxygen interference check gas specifications are found in § 86.308.

(1) Zero the analyzer.

(2) Span the analyzer with an oxygen interference check gas. For instruments used with gasoline-fueled engines use the 0 percent oxygen blend; Diesel engine instruments are spanned with the 21% oxygen blend.

(3) Recheck zero response. If it has changed more than 0.25 percent of full-scale repeat subparagraphs (1) and (2).

(4) Introduce the following oxygen interference check gases: (i) Gasoline-fueled engine analyzers; 5 and 10 percent oxygen blends.

(ii) Diesel engine analyzers; 5, 10 and 15 percent oxygen blends.

(5) Recheck the zero response. If it has changed more than 0.25 percent of full-scale, repeat the test.

(6) Calculate the percent of oxygen interference (%O_2I) for each mixture in step (4).

$$\%O_2I=\frac{B-\text{Analyzer response (ppm C)}}{B}(100)$$

$$\text{Analyzer response}=\left[\frac{A}{\%\text{ of full-scale analyzer response due to A}}\right]\left[\%\text{ of full-scale analyzer response due to B}\right](100)$$

where

A = Hydrocarbon concentration (ppm C) of the span gas used in Step (2)

B = Hydrocarbon concentration (ppm C) of the oxygen-interference check gases used in step(4)

(7) The percent of oxygen interference (%O_2I) must be less than ±2% for all required oxygen interference check gases prior to testing.

(8) If the oxygen interference is greater than the specifications, incrementally adjust the air flow above and below the manufacturer's specifications, repeating subparagraphs (1) through (7) for each flow.

(9) If the oxygen interference is greater than the specification after adjusting the air flow, vary the fuel flow and thereafter the sample flow, repeating subparagraphs (1) through (7) for each new setting.

(10) If the oxygen interference is still greater than the specifications, repair or replace the analyzer, FID fuel, or burner air prior to testing. Repeat this section with the repaired or replaced equipment or gases.

(e) Linearity check. For each range used check linearity as follows: (1) With the fuel flow, air flow and sample flow adjusted to meet the oxygen interference specification, zero the analyzer.

(2) Span the analyzer using a calibration gas that will provide a response of approximately 90 percent of full-scale concentration.

(3) Recheck the zero response. If it has changed more than 0.25 percent of full-scale, repeat steps (1) and (2).

(4) Record the response of calibration gases having nominal concentrations of 30, 60, and 90 percent of full-scale concentration.

(5) Perform a linear least square regression on the data generated. Use an equation of the form $y=mx$, where x is the actual chart deflection and y is the concentration.

(6) Use the equation $z=y/m$ to find the linear chart deflection (z) for each calibration gas concentration (y).

(7) Determine the linearity (%L) for each calibration gas by:

$$\%L=\frac{(Z-X)}{\text{Full-Scale Linear Chart Deflection}}(100)$$

(8) The linearity criteria is met if the %L is less than ±2 percent for any data point generated. For each emission test, a calibration curve of the form $y=mx$ is to be used. The slope (m) is defined for each range by the spanning process.

(9) If the %L for any point is greater than ±2%, the air, fuel, and sample flow-rates may be varied within the boundaries of the oxygen interference specifications.

(10) If the %L still exceeds ±2 percent for any data point repair or replace the analyzer, FID fuel, burner air, or calibration bottles prior to testing. Repeat the procedures of this section with the repaired or replaced equipment or gases.

(f) Optimized flow rates. The fuel-flow rate, air flow-rate and sample-flow rate are defined as "optimized" at this point.

§ 86.332–79 Oxides of nitrogen analyzer calibration.

(a) Perform a converter efficiency check, paragraph (b) of this section, every 7 days. Every 30 days perform a linearity check, paragraph (c) of this section, which must be followed by a converter efficiency check.

(b) *Converter efficiency check.* The apparatus described and illustrated in Figure D79–4 is to be used to determine the conversion efficiency of devices that convert NO_2 to NO. The following procedure is to be used for determining the values to be used in the equation below:

(1) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer.

(3) Connect the outlet of the NOx generator (see Figure D79–4) to the sample inlet of the oxides of nitrogen analyzer which has been set to the most common operating range.

(4) Introduce into the NOx generator analyzer-system a span gas with a NO concentration equal to approximately 80% of the most common operating range.

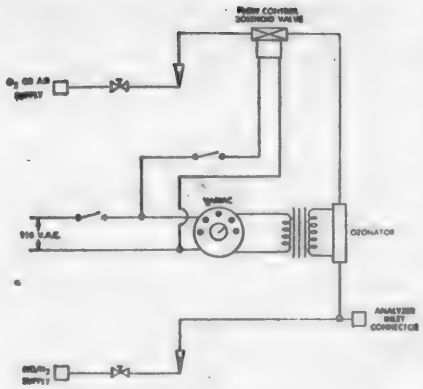

FIGURE D79-4 NOx CONVERTER EFFICIENCY DETECTOR

(5) With the oxides of nitrogen analyzer in the NO mode, record the concentration of NO indicated by the analyzer.

(6) Turn on the NOx generator O_2 (or air) supply and adjust the O_2 (or air) flow rate so that the NO indicated by the analyzer is about 10% less than indicated in step 5. Record the concentration of NO in this NO+O_2 mixture.

(7) Switch the NOx generator to the generation mode and adjust the generation rate so that the NO measured on the analyzer is 20% of that measured in step 5. There must be at least 10% unreacted NO at this point. Record the concentration of residual NO.

(8) Switch the oxides of nitrogen analyzer to the NOx mode and measure total NOx. Record this value.

(9) Switch off the NOx generation, but maintain gas flow through the system. The oxides of nitrogren analyzer will indicate the total NOx in the NO+O_2 mixture. Record this value.

(10) Turn off the NOx generator O_2 (or air) supply. The analyzer will now indicate the total NOx in the original NO in N_2 mixture. This value should be no more than 5% above the value indicated in step 4.

(11) Calculate the efficiency of the NO_2 converter by substituting the concentrations obtained into the following equation:

$$\% \text{ Eff.} = 1 + \frac{a-b}{c-d} \times 100$$

where a = concentration obtained in step 8
b = concentration obtained in step 9
c = concentration obtained in step 6
d = concentration obtained in step 7

The efficiency of the converter should be greater than 90 percent. Adjustment of the converter temperature may be necessary to maximize the efficiency. If the converter does not meet conversion-efficiency specifications, repair or replace the unit prior to testing. Repeat the procedures of this section with the repaired or new converter.

(c) *Linearity check.* For each range used check linearity as follows:

(1) With the operating parameters adjusted to meet the converter efficiency check and the quench checks, zero the analyzer.

(2) Span the analyzer using a calibration gas that will give a response to approximately 90 percent of full-scale concentration.

(3) Recheck the zero response. If it has changed more than 0.25 percent of full-scale, repeat steps (1) and (2).

(4) Record the response of calibration gases having nominal concentrations of 30, 60, and 90 percent of full-scale concentration.

(5) Perform a linear least squares regression on the data generated. Use an equation of the form $y=mx$, where x is the actual chart deflection and y is the concentration.

(6) Use the equation $z=y/m$ to find the linear chart deflection (z) for each calibration gas concentration (y).

(7) Determine the linearity (%L) for each calibration gas by:

$$\%L = \frac{(z-x)}{\text{Full scale linear chart deflection}} \times 100$$

(8) The linearity criteria is met if the %L is less than ±2 percent for any data point generated. For each emission test, a calibration curve of the form $y=mx$ is to be used. The slope (m) is defined for each range by the spanning process.

(9) If the %L exceeds ±2 percent for any data point generated, repair or replace the analyzer or calibration bottles prior to testing. Repeat the procedures of this section with the repaired or replaced equipment or gases.

(10) Perform a converter efficiency check, paragraph (b) of this section.

(11) The operating parameters are defined as "optimized" at this point.

§ 86.333–79 Dynamometer calibration.

(a) If necessary, follow the manufacturer's instructions for initial start-up and basic operating adjustments.

(b) Check the dynamometer torque measurement for each range used by the following:

following: (1) Determine the dynamometer calibration moment arm. Equipment manufacturer's data, actual measurement, or the value recorded from the previous calibration used for this subpart may be used.

(2) Warm up the dynamometer following the equipment manufacturer's specifications.

(3) Calculate the indicated torque (IT) for each calibration weight to be used by:

IT=calibration weight (lb) × calibration moment arm (ft.)

(4) Attach each calibration weight specified in § 86.312 to the moment arm at the calibration distance determined in step (1). Record the power measurement equipment response (ft-lb) to each weight.

(5) For each calibration weight, compare the torque value measured in step (4) to the calculated torque determined in step (3).

(6) The measured torque must be within 2 percent of the calculated torque.

(7) If the measured torque is not within 2 percent of the calculated torque, adjust or repair the system. Repeat steps 1) through (6) with the adjusted or repaired system.

§ 86.334–79 Test procedure overview.

(a) The test consists of prescribed sequences of engine operating conditions to be conducted on an engine dynamometer. The exhaust gases generated during engine operation are sampled for specific component analysis through the analytical train. The test is applicable to engines equipped with catalytic or direct-flame afterburners, induction system modifications, or other systems, or to uncontrolled engines.

(b) The tests are designed to determine the brake-specific emissions of hydrocarbons, carbon monoxide, and oxides of nitrogen. The gasoline-fueled engine test consists of one warmup cycle and one hot cycle. The diesel engine test consists of three idle modes and five power modes at each of two speeds which span the typical operating range of diesel engines. These procedures require the determination of the concentration of each pollutant, the exhaust flow and the power output during each mode. The measured values are weighted and used to calculate the grams of each pollutant emitted per brake-horsepower hour.

(c) When an engine is tested for exhaust emissions or is operated for service accumulation on an engine dynamometer, the complete engine shall be tested, with all standard accessories which might reasonably be expected to influence emissions to the atmosphere, installed and functioning, except the fan for water cooled engines. Evaporative emission controls need not be connected if data are provided to show that normal operating conditions are maintained in the engine induction system.

(d) Except in cases of component malfunction or failure, all emission control systems installed on or incorporated in a new motor vehicle engine shall be functioning during all procedures in this subpart. Maintenance to correct component failure or malfunction shall be authorized in accordance with § 86.079–25.

§ 86.335–79 Gasoline-fueled engine test cycle.

(a) The following test sequence shall be followed in dynomometer operation tests of gasoline-fueled heavy duty engines. Diesel engines are covered in § 86.336.

Cycle No.	Mode No.	Mode	Observed torque (percent of maximum observed)	Time in mode (seconds)	Cumulative time (seconds)	Weighting factors
1	1	Idle		60	60	0.232
1	2	Cruise	25	60	120	.077
1	3	PTA	55	60	180	.147
1	4	Cruise	25	60	240	.077
1	5	PTD	10	60	300	.057
1	6	Cruise	25	60	360	.077
1	7	FL	90	60	420	.113
1	8	Cruise	25	60	480	.077
1	9	CT		60	540	.143
2	10	Cruise	25	60	600	.077
2	11	PTA	55	60	660	.147
2	12	Cruise	25	60	720	.077
2	13	PTD	10	60	780	.057
2	14	Cruise	25	60	840	.077
2	15	FL	90	60	900	.113
2	16	Cruise	25	60	960	.077
2	17	CT		60	1,020	.143
2	18	Idle		60	1,080	.232

(b) The engine dynamometer shall be operated at a constant speed of 2000 r.p.m. ±100 r.p.m. Speed deviations, not to exceed 200 r.p.m., will be allowed during the first ten seconds of each mode.

(c) The times in mode are the times specified in paragraph (a) ±2 seconds.

(d) Torque for each mode must be held at the specified value ±2% of the maximum torque observed. For example, mode 3 torque shall be held between 53 and 57% of maximum torque (55±2%).

(e) The idle operating mode shall be carried out at the manufacturer's recommended curb-idle engine speed. Arrive at the last idle mode by closing the throttle, breaking the dynamometer to the engine idle speed, and unloading the dynamometer.

(f) The CT operating mode shall be carried out at the same engine speed as specified in paragraph (b).

§ 86.336–79 Diesel engine test cycle.

(a) The following 13 mode cycle shall be followed in dynamometer operation tests of heavy-duty Diesel engines. Gasoline-fueled engines are covered in § 86.335.

Mode No.	Engine speed	Observed torque (percent of maximum observed)	Time in mode (minutes)	Cumulative time (minutes)
1	Low idle		5	5
2	Intermediate	2	5	10
3	....do	25	5	15
4	....do	50	5	20
5	....do	75	5	25
6	....do	100	5	30
7	Low idle		10	(1)
8	Rated	100	5	5
9	....do	75	5	10
10	....do	50	5	15
11	....do	25	5	20
12	....do	2	5	25
13	Low idle		5	30

[1] Refer to sec. 86.341.

(b) During each mode the specified speed shall be held to within 50 rpm. Torque for each mode must be held at the specified value ±2% of the maximum torque observed. For example, mode 4 torque shall be held between 48 and 52 percent of maximum torque (50±2%).

(c) The times in mode are the times specified in paragraph (a) ±10 seconds.

(d) If the operating conditions specified in paragraph (b) of this section for modes 3, 4, 5, 9, 10, and 11 cannot be maintained, the Administrator may authorize deviations from the specified load conditions. Such deviations shall not exceed 10 percent of the maximum torque at the test speed. The minimum deviations, above and below the specified load, necessary for stable operation shall be determined by the manufacturer and approved by the Administrator prior to the test run. Emission tests shall be performed at each of the approved load settings, one above and one below the operating conditions specified in paragraph (a). The emission values obtained shall be calculated in accordance with § 86.331 except that the weighting factor shall be 0.04.

§ 86.337–79 Information.

The following information, as applicable, shall be recorded for each test:

(a) Engine Description and specifications. (1) Engine identification numbers.

(2) Number of hours of operation accumulated on engine.

(3) Engine-system combination.

(4) Engine displacement.

(5) Governed speed.

(6) Rated maximum horsepower and torque.

(7) Maximum horsepower and torque speeds.

(8) Air aspiration system.

(9) Curb idle rpm, gasoline-fueled engines only.

(10) Manufacturer's start-up and warm-up reference, gasoline-fueled engines only.

(11) Number of carburetors, gasoline-fueled engines only.

(12) Number of carburetor venturies, gasoline-fueled engines only.

(13) Maximum horsepower at 2000 rpm, corrected per § 86.345, gasoline-fueled engines only.

(14) Fuel consumption and maximum torque at 2000 rpm, gasoline-fueled engines only.

(15) Maximum air flow at 2000 rpm, gasoline-fueled engines only.

(16) Low idle rpm, Diesel engines only.

(17) Exhaust pipe diameter(s), Diesel engines only.

(18) Fuel injector type, Diesel engines only.

(19) Fuel consumption at maximum power and torque, Diesel engines only.

(20) Maximum exhaust system back pressure, Diesel engines only.

(21) Air inlet restriction, Diesel engines only.

(22) Maximum air flow, Diesel engines only.

(b) Test data: (1) Test number.

(2) Instrument operator.

(3) Engine operator.

(4) Date and time of day.

(5) Fuel identification, including H/C ratio.

(6) Ambient temperature in dynamometer testing room.

(7) Engine intake air temperature and humidity for each mode.

(8) Barometric pressure, before and after test.

(9) Observed engine torque for each mode.

(10) Maximum observed torque for intermediate and rated speeds, Diesel engines only.

(11) Maximum observed torque at 2000 rpm, gasoline-fueled engines only.

(12) Intake air flow and depression for each mode.

(13) Fuel flow and temperature for each mode.

(14) Sample-transport component surface temperatures, sample pump, heated filters and sample line temperature(s).

(15) Sample-line residence time (Refer to § 86.329).

(16) Date of most recent analytical assembly calibration.

(17) Record all pertinent instrument information such as tuning, gain, serial numbers, detector number, calibration curve numbers, etc. As long as this information is traceable it may be summarized by system number or analyzer identification numbers.

(18) Recorder chart. Identify for each test mode: zero traces for each range used—calibration or span traces for each range used—emission concentration traces and associated analyzer range(s)—start and finish of each test.

(19) Record chart speed of recorder and date of last speed calibration.

(20) Record engine torque and engine r.p.m. continuously on the same chart.

§ 86.338–79 Exhaust measurement accuracy.

(a) The analyzers must be operated between 20 percent and 95 precent of full-scale chart deflection (millivolt output) for nonlinear instruments (20 to 100 percent for linear instruments) dur-

ing the measurement of the emissions for each mode. The exceptions to the lower limit of this operating rule are:

(1) The analyzers response may be less than 20 precent of full-scale if the full-scale value is 120 ppm (or ppm C) or less.

(2) The analyzers response may be less than 20 percent of full-scale if the emissions from the engine are erratic and the integrated chart-deflection value is greater than 20 percent of full-scale.

(3) For gasoline-fueled engines, the analyzer response may be less than 20 percent of full-scale during the initial part of the CT mode provided that the integrated chart-deflection value is greater than 20 percent of full-scale.

(4) The analyzer response may be less than 20 percent of full-scale if the contribution of all modes read below the 20 percent level is less than 5 percent by mass of the final test results.

§ 86.339–79 Pre-test procedures.

(a) HC, CO, CO_2 and NOx: Allow a minimum of 2 hours warmup for the HC, CO, CO_2 and NOx analyzers. This period is not necessary if the analyzer is left in a standby or operating condition.

(b) Replace or clean the filter elements and then vacuum leak check the system, § 86.328(a). Allow the heated sample-line, filters, and pumps to reach operating temperature.

(c) Perform the following system checks: (1) Prior to gasoline-fueled engine tests, purge the $NO_2 \rightarrow NO$ converter with air (zero grade air, room air, or O_2) for a minimum of 30 minutes. The converter must be at operational temperature while purging. Minimum purge-rate is 40 cc/minute.

(2) Check sample-line temperature.

(3) Check sample-line residence time. Sample-line residence time may be applied from the most recent check of residence time if all of the following are met: (i) The same size and type of pump is used.

(ii) The sample line I.D. is the same and the length is equal to or shorter than the tested line.

(iii) Pressure gauges P1, P2, P3, P4, and P5 read the same pressure (±15% of previous value).

(4) A hang-up check may be performed.

(d) Introduce the zero-grade gases at the same flow rates and pressures used to calibrate the analyzers and zero the analyzers on the lowest anticipated range that may be used during the test. Immediately prior to each test (segment, for Diesel engines), obtain a stable zero for each anticipated range that may be used during the test.

(e) Introduce span gases to the instruments under the same flow conditions as were used for the zero gases. Adjust the instrument gains on the lowest range to be used to give the desired value. Span-gases should have a concentration greater than 70% of full-scale for each range used. A significant shift in gain setting indicates an instrument or system problem. If necessary, recheck spanning procedure and span-gas concentration-labels. Immediately prior to each test and also prior to each segment of the diesel test, record the response to the span-gas and the span-gas concentration for each range that may be used during the test.

(f) Check zero responses. If they have changed more than 0.25 percent of full scale repeat paragraphs (d) and (e).

(g) Check instrument flow rates and pressures. Record the values of gauges G1 and G2.

§ 86.340–79 Gasoline-fueled engine dynamometer test run.

(a) This section applies to gasoline-fueled engines only. Diesel engines are covered in § 86.341.

(b) (1) Mount test engine on the engine dynamometer.

(2) Install instrumentation and sample probe as probed.

(c) Precondition the engine by the following continuous steps. (1) The engine shall be started and operated at: (i) zero load in accordance with the manufacturer's start up and warm up procedures for 1 minute ±30 sec.

(ii) a torque equivalent to 10±3 percent of the most recent determination of maximum torque for 4 miputes ±30 sec at 2000 rpm.

(iii) a torque equivalent to 55±5 percent of the most recent determination of maximum torque for 35 minutes ±1 min at 2000 rpm.

(2) If tested under the provisions of § 86.077–29 check specifications as required. This check must be performed within 10 minutes after the completion of engine preconditioning.

(3) Determine the maximum torque of the engine at 2000 rpm ±100 rpm.

(i) Operate the engine with the throttle fully-opened for a maximum of three minutes. During the second minute of operation, record the high and low torque readings. The average of these two readings will be the maximum torque value at 2000 rpm.

(ii) Calculate the torque corresponding to 10, 25, 55, and 90 percent of the observed maximum torque value.

(4) Determine the analyzer ranges required for each mode specified in § 86.335 to meet the range specifications of § 86.338. The engine must not be operated for more than 5 minutes.

(5) The engine shall be turned off and allowed to stand for at least 1 hour, but not more than 2 hours, at an ambient temperature of 25°C ±5°C (77°F±9°F).

(d) The following steps shall be taken for each test:

(1) Maintain dynometer test cell ambient temperature at 25°C±5°C (77°F±9°F).

(2) Observe pre-test procedures, § 86.339.

(3) Start cooling system.

(4) Start engine and operate in accordance with manufacturer start-up and warm-up procedures. The duration of the warm-up procedure will be 5 minutes ±30 seconds.

(5) Read and record all non-modal data as required in § 86.337.

(6) Release the choke idle-stop (if necessary) and return the engine throttle control to the curb idle position, start sample flow and recorders, and begin test sequence of § 86.335.

(7) Should it be determined that the test must be rerun, then only the soak specified in subparagraph (c)(5) need be performed prior to paragraph (d).

(8) Perform the test cycle, § 86.335 and continuously record exhaust gas concentrations.

(9) The engine speed and load must be maintained within the requirements of § 86.343.

(e) *Exhaust gas measurements.* (1) Measure HC, CO, CO_2, and NOx volume concentration in the exhaust sample. Record data specified in § 86.337. Should the analyzer response exceed 95% of full-scale value for non-linear instruments (100% of full-scale value for linear instruments) or respond less than 20% of full-scale value (for all instruments), the next higher or lower analyzer range shall be used per § 86.338. For exceptions to the lower limit see § 86.338. Should the fuel flow instrument read below 20% of the full-scale value, a flow measurement unit with a lower scale must be used unless the option in § 86.314 is desired.

(2) For each analyzer, each range that may be used during a test must have the zero and span responses recorded prior to the execution of that test. Only the range(s) used to measure the emissions during a test are required to have their zero and span recorded after the completion of the test.

(3) If during an emission test the value of guages G1 or G2 differs by more than 4 inches of water from the pre-test value the test is void.

§ 86.341–79 Diesel engine dynamometer test run.

(a) This section applies to Diesel engines only. Gasoline-fueled engines are covered in § 86.340.

(b) The temperature of the air supplied to the engine shall be between 68°F and 86°F. The fuel temperature at the pump inlet shall be 100°F ±10°F. The observed barometric pressure shall be between 28.5 inches and 31 inches Hg. Higher air temperature or lower barometric pressure may be used, if desired, but no allowance shall be made for increased emissions because of such conditions.

(c) The governor and fuel system shall have been adjusted to provide engine performance at the levels in the application for certification required under § 86.077–21.

(d) The following steps shall be taken for each test: (1) Install instrumentation and sample probes as required.

(2) Start cooling system.

(3) Precondition the engine in the following manner: (i) Operate the engine at idle for 2 minutes.

(ii) Operate the engine at rated speed and maximum horsepower for 10 minutes.

(iii) Longer preconditioning times may be used only if prior approval is obtained from the Administrator.

(4) Within a total elapsed time of 10 minutes, determine by experimentation the maximum torque at the rated and intermediate speeds.

(5) Calculate the torque corresponding to 2, 25, 50, 75, and 100 percent of the maximum observed torque for the rated and intermediate speeds.

(6) Observe pre-test procedures, § 86.339.

(7) Read and record all data required by § 86.337.

(8) Start the test cycle, § 86.336, within 10 minutes, after determining test load using the torque values determined in subparagraph (c)(5).

(9) Test modes 1 through 6, mode 7, and modes 8 through 13 are considered individual test segments and must be performed within the cumulative time indicated in § 86.336. Test segments may be repeated if the requirements for testing under this subpart are met.

(10) If a delay of more than 10 minutes occurs at the following points, the test is void. The test sequence may be restarted at subparagraph (c)(6).

(i) At the end of mode 6 and the beginning of modes 1 or 7.

(ii) At the end of mode 7 and the beginning of modes 1 or 8.

(iii) At the end of mode 13 and the beginning of mode 8.

(11) Continuously record the analyzer's response to the exhaust gas during each test segment except during mode 7.

(12) Record the analyzer's response to exhaust gas during the last 4 minutes of mode 7.

(13) Read and record the modal data as specified in § 86.337 during the last 2 minutes of each mode.

(14) The engine speed and load must be maintained within the requirements of § 86.336 during the last 2 minutes of each mode. If the requirement is not met for all modes during a test segment, that portion of the test is void. The test sequence may be restarted under the provisions of subparagraph (c)(9) of this section.

(15) Fuel flow during the idle or 2 percent load conditions may be determined just prior to or immediately following the dynamometer sequence, if longer times are required for accurate measurements.

(e) *Exhaust gas measurements.* (1) Measure HC, CO, CO_2, and NOx volume concentration in the exhaust sample. Record data specified in § 86.337. Should the analyzer response exceed 95% of full scale value for nonlinear instruments (100% of full-scale value for linear instruments) the next higher or lower analyzer range shall be used § 86.338. For exceptions to the lower limit see § 86.338. Should the fuel flow instrument read below 20% of full-scale value, a smaller flow measurement unit must be used unless the option in § 86.314 is desired.

(2) Each analyzer range that may be used during a test segment must have the zero and span responses recorded prior to the execution of that test segment. Only the range(s) used to measure the emissions during a test segment are required to have their zero and span recorded after the completion of the test segment.

(3) The span check for mode 7 may be included in either the first segment or the last segment of the test.

(4) If there is no delay between the end and beginning of modes 6 and 7, and 7 and 8, the span check at the end of mode 6 may be used for the before-segment span check for the last segment of the test.

(5) Filter elements may be changed during the first part of mode 7.

(6) If, during the emission measurement portion of a test segment, the value of gauges of G1 or G2 differs by more than 4 inches of water from the pre-test value the test segment is void.

§ 86.342–79 Post-test procedures.

(a) Immediately after the completion of the test, record for each analyzer the zero and span response for each range used during the preceding test segment.

(b) Begin a hang-up check within 10 minutes of the completion of the post-test span check. Use the following procedure:

(1) Zero the HC analyzer on the lowest range used during the test.

(2) Span the HC analyzer.

(3) Check zero response. If it has shifted more than 0.25 percent of full scale, repeat steps (1) and (2).

(4) Introduce an HC zero-grade gas into the sample probe or V2.

(5) Within 50 seconds for gasoline-fueled engine tests or 4 minutes for Diesel engine tests, after the zero gas was introduced, the difference between the span-zero response and hang-up zero response must not be greater than 5.0 percent of full-scale or the test is void.

(6) Check the zero response. If it has shifted more than 0.25 percent of full scale repeat the hang-up check.

(c) If during the test, the filter element(s) were replaced or cleaned, a vacuum check must be performed, see § 86.328, immediately after the hang up check. If the vacuum side leak-check does not meet the requirements of § 86.328 the test is void.

(d) For a valid test, the analyzer drift between the before-test and after-test (before segment and after-segment for Diesels) span-checks for each analyzer must meet the following requirements:

(1) The span drift (defined as the difference between the zero-response and the span-response) must not exceed 2.0 percent of full-scale for each range used.

(2) The zero-response drift must not exceed 2.0 percent of full-scale.

(i) If the zero-response drift is less than 2.0 percent of full scale the before-segment zero response is to be used.

(ii) If the zero-response drift is between 2.0 and 6.0 percent of full-scale, a zero-response correction based on an interpolation which is linear with time is acceptable.

§ 86.343–79 Chart reading.

(a) A computer or any other automatic data processing device(s) may be used as long as the system meets the requirements of this subpart.

(b) Determine the location on the chart of the analyzer responses corresponding to the end of each mode.

(c) For gasoline-fueled engines determine whether the test cycle was run in accordance with § 86.335 by observing either chart event marks, speed trace, torque trace, or concentration traces. The test will be invalidated if there is a deviation by more than:

(1) two seconds from the specified time for each mode, or

(2) 2 percent of maximum torque during each mode excluding the first 10 seconds of each mode, or

(3) 200 rpm during the first 10 seconds of each mode, or 100 rpm during the remainder of each mode.

(d) Determine chart deflections. (1) Locate the last 10 seconds of each gasoline-fueled engine mode except CT. Locate the last 50 seconds of each gasoline-fueled engine CT mode. For all Diesel engine modes locate the last 60 seconds.

(2)(i) Determine for each second (or less) the percent of full scale deflection of the CO_2 CO, HC, and NOx analyzers for each mode time period.

(ii) Option for Diesel engine modes: If the deviation from a constant value straight line (other than instrument noise) during this 60 seconds is less than ±5 percent of full scale, a simple average of the interpreted straight line may be used as the chart deflection for the entire 60 seconds. For linear instruments the straight line need not be constant value.

(3) Other methods of determining the percent of full-scale deflection of the analyzers may be used only with prior approval by the Administrator.

(e) Determine CO_2 CO HC and NOx concentrations. (1) For linear instruments, average the chart deflections for each mode time period. Determine the concentration for this average chart deflection using calibration data.

(2) For non-linear instruments, calculate concentrations for each chart deflection during each mode time period. Take the average of these concentrations.

(3) If the option in subparagraph (d)(2)(ii) is employed, then those chart deflections are applied to this paragraph.

(4) For purposes of this paragraph, calibration data includes calibration curves, linearity curves, span gas response and zero shift corrections.

§ 86.344–79 Humidity calculations.

(a) The following abbreviations (and units) are used in this section:

BARO = Barometric pressure (Pa)
H = Specific humidity (gm H_2O/gm of dry air)
K = 0.6219 gm H_2O/gm dry air
M_{air} = Molecular weight of air = 28.967
M_{H_2O} = Molecular weight of water = 18.01534
P_{DB} = Saturation vapor pressure of water at the dry bulb temperature (Pa)
P_{DP} = Saturation vapor pressure of water at the dewpoint temperature (Pa)
Pv = Partial pressure of water vapor (Pa)
P_{WB} = Saturation vapor pressure of water at the wet bulb temperature (Pa)
T_{DB} = Dry bulb temperature (°K)
T_{WB} = Wet bulb temperature (°K)
Y = Water-vapor volume concentration

(b) The specific humidity (H) is defined by equation (1).

$$H=\frac{KPv}{BARO-Pv} \quad (1)$$

(c) The partial pressure of water vapor may be determined in two manners:

(1) A dew point device may be used. In that case:

$$P_v=P_{DP}$$

(2) A wet-bulb, dry-bulb method may be used. In that case "Ferrels equation" (eq. (2)) is used.

$$P_v=P_{WB}-0.000660(T_{DB}-T_{WB})BARO\,(1+0.00115(T_{WB}-273.15)) \quad (2)$$

(d)(1) The saturation vapor pressure (P_{WB}) of water at the wet-bulb temperature is defined by equation (3) (Ref. Waxler and Greenspan, equation (23), National Bureau of Standards).

$$P_{WB}=\exp\left[B\ln T_{WB}+\sum_{i=0}^{9}F_iT_{WB}^{i-2}\right] \quad (3)$$

where (P_{WB} is in Pascals (Pa))

T_{WB} = Wet-bulb temperature (°K)
$B=-12.150799$
$F_0=-8.49922(10)^1$
$F_1=-7.4231865(10)^3$
$F_2=96.1635147$
$F_3=2.4917646(10)^{-2}$
$F_4=-1.3160119(10)^{-6}$
$F_5=-1.1460454(10)^{-6}$
$F_6=2.1701289(10)^{-11}$
$F_7=-3.6102258(10)^{-15}$
$F_8=3.8504519(10)^{-18}$
$F_9=-1.4317(10)^{-21}$

(2) The table in Figure D79-5 may be used in lieu of equation (3).

(e) The saturated vapor pressure of water at the dry-bulb temperature (P_{DB}) is found (if required) by using dry-bulb absolute temperature (°K) in equation (3).

(f) The percent of relative humidity (RH) (if required) is defined by equation (4).

$$RH=\frac{P_v}{P_{DB}}(100) \quad (4)$$

(g) The water-vapor volume concentration of the engine intake air (Y) is defined by equation (5).

$$Y=\frac{(H)(M_{air})}{(M_{H_2O}}=\frac{P_v}{BARO-P_v} \quad (5)$$

FIGURE D79–5.—*Saturation vapor pressure over water (pascals)*

Temperature °C	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	610.752	615.207	619.690	624.203	628.744	633.315	637.916	642.545	647.205	651.894
1	656.614	661.364	666.144	670.956	675.796	680.669	685.572	690.507	695.473	700.471
2	705.500	710.562	715.655	720.781	725.939	731.130	736.354	741.611	746.901	752.224
3	757.581	762.971	768.396	773.854	779.347	784.874	790.436	796.033	801.664	807.331
4	813.034	818.771	824.545	830.355	836.200	842.082	848.001	853.956	859.948	865.978
5	872.045	878.149	884.291	890.470	896.688	902.945	909.239	915.573	921.945	928.357
6	934.808	941.298	947.828	954.399	961.009	967.660	974.351	981.083	987.856	994.670
7	1,001.53	1,008.42	1,015.36	1,022.34	1,029.37	1,036.43	1,043.54	1,050.70	1,057.89	1,065.13
8	1,072.41	1,079.74	1,087.11	1,094.52	1,101.98	1,109.48	1,117.03	1,124.63	1,132.27	1,139.95
9	1,147.68	1,155.46	1,163.28	1,171.15	1,179.07	1,187.04	1,195.05	1,203.11	1,211.21	1,219.37
10	1,227.57	1,235.83	1,244.13	1,252.48	1,260.88	1,269.32	1,277.82	1,286.37	1,294.97	1,303.62
11	1,312.32	1,321.07	1,329.87	1,338.73	1,347.63	1,356.59	1,365.60	1,374.67	1,383.78	1,392.95
12	1,402.17	1,411.45	1,420.78	1,430.16	1,439.60	1,449.10	1,458.64	1,468.25	1,477.91	1,487.62
13	1,497.39	1,507.22	1,517.11	1,527.05	1,537.04	1,547.10	1,557.21	1,567.39	1,577.62	1,587.93
14	1,598.25	1,608.66	1,619.12	1,629.65	1,640.24	1,650.88	1,661.59	1,672.36	1,683.18	1,694.06
15	1,705.03	1,716.04	1,727.12	1,738.26	1,749.46	1,760.73	1,772.06	1,783.45	1,794.91	1,806.48
16	1,818.01	1,829.67	1,841.38	1,853.17	1,865.02	1,876.93	1,888.91	1,900.96	1,913.08	1,925.27
17	1,937.52	1,949.84	1,962.23	1,974.69	1,987.21	1,999.81	2,012.48	2,025.21	2,038.02	2,050.90
18	2,063.85	2,076.87	2,089.97	2,103.13	2,116.37	2,129.68	2,143.07	2,156.53	2,170.06	2,183.66
19	2,197.34	2,211.10	2,224.93	2,238.84	2,252.82	2,266.88	2,281.02	2,295.23	2,309.52	2,323.89
20	2,338.34	2,352.86	2,367.47	2,382.15	2,396.91	2,411.76	2,426.68	2,441.68	2,456.77	2,471.93
21	2,487.18	2,502.51	2,517.93	2,533.42	2,549.00	2,564.66	2,580.41	2,596.24	2,612.16	2,628.16
22	2,644.25	2,660.42	2,676.68	2,693.02	2,709.46	2,725.98	2,742.59	2,759.28	2,776.07	2,792.94
23	2,809.91	2,826.96	2,844.11	2,861.34	2,878.67	2,896.09	2,913.60	2,931.20	2,948.89	2,966.68
24	2,984.56	3,002.54	3,020.61	3,038.77	3,057.03	3,075.39	3,093.84	3,112.39	3,131.03	3,149.78
25	3,168.62	3,187.55	3,206.59	3,225.73	3,244.96	3,264.30	3,283.73	3,303.27	3,322.91	3,342.65
26	3,362.49	3,382.43	3,402.48	3,422.63	3,442.89	3,463.24	3,483.71	3,504.28	3,524.95	3,545.73
27	3,566.62	3,587.62	3,608.72	3,629.93	3,651.25	3,672.67	3,694.21	3,715.86	3,737.61	3,759.48
28	3,781.46	3,803.55	3,825.75	3,848.07	3,870.50	3,893.04	3,915.70	3,938.47	3,961.36	3,984.36
29	4,007.48	4,030.71	4,054.06	4,077.53	4,101.12	4,124.83	4,148.65	4,172.59	4,196.66	4,220.84
30	4,245.15	4,269.58	4,294.13	4,318.80	4,343.60	4,368.52	4,393.56	4,418.73	4,444.02	4,469.44

§ 86.345–79 Emission calculations.

(a) The following abbreviations (and units) are used in this section.

α = Atomic hydrogen/carbon ratio of the fuel
ϕ = Dry fuel-air ratio (measured)/fuel-air ratio (stoichiometric)
BARO = Barometric pressure (in. Hg A)
BHP = Brake horsepower
BSCO = Brake specific carbon monoxide emissions, (gm/BHP-HR)
BSFC = Brake specific fuel consumption (lb/BHP-HR)
BSHC = Brake specific hydrocarbon emissions (gm/BHP-HR)
BSNOx = Brake specific oxides of nitrogen emissions (gm/BHP-HR)
DCO = CO volume concentration in exhaust, ppm (dry)
DCO_2 = CO_2 volume concentration in exhaust, % (dry)
DHC = HC volume carbon concentration in exhaust, ppm C (dry)
DKNO = NO volume concentration in exhaust, in ppm (dry and humidity corrected)
EIP = Engine intake pressure (in. Hg A) = BARO − inlet depression.
f/a = Measured dry fuel-air ratio
H = Humidity of the inlet air in grain of water per pound of dry air = (0.0748/453.59) (gm. H_2O/gm. air)
K = Water − gas equilibrium constant = 3.5
K_{NOx} = Humidity correction factor for oxides of nitrogen
K_w = Wet to dry correction factor
M_C = Atomic weight of carbon
(M_C+M_H) = Mean molecular weight of the fuel per carbon atom
M_{CO} = Atomic weight of CO
M_H = Molecular weight of hydrogen
M_{NO_2} = Molecular weight of nitrogen dioxide (NO_2)
T = Temperature of inlet air °F
W_{CO} = Mass rate of CO in exhaust, grams/hr.
W_f = Mass flow rate of fuel used in the engine, grams/hr = (453.59)× (W_f lbs/hr)
WHC = HC volume concentration in exhaust, ppm C (wet)
W_{HC} = Mass rate of HC in exhaust, grams/hr
W_{NOx} = Mass rate of NOx in exhaust, grams/hr
Y = H_2O volume concentration of intake air, % (see § 86.344)

(b) Determine the exhaust species volume concentration for each mode.

(c) Convert the measured hydrocarbon (HC) volume concentrations to a dry basis per the following:

Wet-concentrations = Kw × dry-concentrations

Kw is defined by the equation in Figure D79-6.

(d) Multiply the dry nitric oxide volume concentrations by the following humidity correction factor: (1) Gasoline-fueled engines:

$$K_{NO_x}=0.6272+0.00629H-0.0000176H^2$$

(2) Diesel engines:

$$K_{NO_x}=\frac{1}{1+A(H-75)+B(T-85)}$$

where

A = 0.044 (f/a) − 0.0038
B = −0.116 (f/a) + 0.0053
T = Temperature of inlet air, °F.

(e)(1) Compute the dry (f/a) as follows:

$$K_W = \frac{1}{1 + \left[\frac{\alpha\left(\frac{DCO_2}{10^2} + \frac{DCO}{10^6}\right) \div \frac{2Y}{\emptyset}\left(\frac{DCO_2}{10^2} + \frac{DCO}{10^6} + \frac{WHC}{10^6}\right)\left(1 + \frac{\alpha}{4}\right)}{2\left(1 + \frac{\frac{DCO}{10^6}}{\left(\frac{DCO_2}{10^2}\right)K}\right)}\right]}$$

Figure D79-6 K_W - WET TO DRY CORRECTION FACTOR

$$(f/a) = \frac{4.77\left(1 + \frac{\alpha}{4}\right)(f/a)_{stoich}}{\frac{1}{\bar{X}} - \left(\frac{DCO}{2\bar{X}(10)^6}\right) - \left(\frac{DHC}{\bar{X}\,10^6}\right) + \frac{\alpha}{4}\left(1 - \frac{DHC}{\bar{X}(10^6)}\right) - \frac{.75\,\alpha}{\left(\frac{K}{\frac{DCO}{\bar{X}(10)^6}}\right) + \left(\frac{(1-K)}{1 - \frac{DHC}{\bar{X}(10)^6}}\right)}}$$

$$(f/a)_{stoich} = \frac{M_C + \alpha M_H}{138.18\left(1 + \frac{\alpha}{4}\right)}$$

where

$$\bar{X} = DCO_2/10^2 + DCO/10^6 + DHC/10^6$$

(2) When calculating the (f/a) ratio to be used in determining K_w, use only the airflow entering the combustion chamber. This may require subtraction of bleed-air, etc. from the measured airflow.

(f) (1) Data validation: Compare the calculated dry (f/a) with the measured fuel and air flow. For a valid test the emission calculated (f/a) must agree within 10% of the measured (f/a) for each mode. Gasoline-fueled engine idle and CT modes and Diesel engine idle and 2 percent modes do not have to meet this requirement.

(2) Fuel/Air ratio comparison: When comparing measured (f/a) ratio to an emissions calculated (f/a) ratio, the measured airflow (in terms of mass) is the total mass of air entering the exhaust pipe. This may include additions of air mass to the exhaust pipe by an air injection system.

(g) Calculate the mass emissions of each species in grams per hour for each mode as follows:

(1) HC grams/hr $= W_{HC} = \frac{\frac{DHC}{10^4} W_f}{\frac{DCO}{10^4} + DCO_2 + \frac{DHC}{10^4}}$

(2) CO grams/hr $= W_{CO} = \frac{M_{CO}\frac{DCO}{10^4} W_f}{(M_C + \alpha M_H)\left(\frac{DCO}{10^4} + DCO_2 + \frac{DHC}{10^4}\right)}$

(3) NOx grams/hr $= W_{NOx} = \frac{M_{NO_2}\frac{DKNO}{10^4} W_f}{(M_C + \alpha M_H)\left(\frac{DCO}{10^4} + DCO_2 + \frac{DHC}{10^4}\right)}$

(h) (1) For gasoline-fueled engines. Weight the mass values of BHP, W_{HC}, W_{CO}, W_f, and W_{NOx} for each mode by multiplying the modal mass values by the appropriate modal weighting factor prescribed by § 86.335.

(2) For Diesel fueled engines. Weight the values of BHP, W_{HC}, W_{CO}, W_{NOx}, and W_f as follows:

(i) Average the values obtained from the three idle modes and multiply this value by (0.2/3). Substitute this value for each of the three idle modes.

(ii) Weight the remaining modes by multiplying the values by 0.08.

(i) Calculate the brake specific emissions for

(1) each gasoline-fueled engine test cycle, and

(2) each Diesel engine test by summing the weighted values (BHP, W_{HC}, W_{CO}, and W_{NOx}) from each mode as follows:

$$BSHC(i) = \frac{\Sigma \text{ weighted } W_{HC}}{\Sigma \text{ weighted BHP}}$$

$$BSCO(i) = \frac{\Sigma \text{ weighted } W_{CO}}{\Sigma \text{ weighted BHP}}$$

$$BSNOx(i) = \frac{\Sigma \text{ weighted } W_{NOx}}{\Sigma \text{ weighted BHP}}$$

(i) = Test cycle number (i=1, 2), gasoline-fueled engines only.

(j) Calculate the brake specific fuel consumption (BSFC) from the non-weighted BHP and W_f for each mode. Gasoline-fueled engine idle and CT modes and Diesel idle modes are excluded.

$$BSFC = \frac{W_f}{\text{Corrected BHP}}$$

where

$$\text{Corrected BHP} = BHP\left[\frac{29.00}{EIP}\right]\left[\frac{T + 459.69}{85 + 459.69}\right]^n$$

where

$n = 0.5$ for gasoline-fueled engines

$= 0.7$ for diesel engines

(2) Other methods of correcting power to determine BSFC may be used only with prior approval of the Administrator.

(k) Calculate the weighted brake specific fuel consumption (WBSFC) for

(1) each gasoline engine test cycle, and

(2) each diesel engine test by summing the weighted values (W_f and corrected BHP) from each mode as follows:

$$WBSFC(i) = \frac{\Sigma \text{ weighted } W_f}{\Sigma \text{ weighted corrected BHP}}$$

W_f = Fuel flow in lb/hr

(i) = Test cycle number (i=1,2), gasoline-fueled engines only.

(l) For gasoline-fueled engines. Calculate the brake specific emissions and fuel consumption for the complete test as follows:

BSHC(T) = 0.35 BSHC(1) + 0.65 BSHC(2)
BSHC(T) = 0.35 BSHC(1) + 0.65 BSHC(2)
BSCO(T) = 0.35 BSCO(1) + 0.65 BSCO(2)
BSNOx(T) = 0.35 BSNOx(1) + 0.65 BSNOx(2)
WBSFC(T) = 0.35 WBSFC(1) + 0.65 WBSFC(2)

12. The title to Subpart H is revised to read as follows:

Subpart H—Emission Regulations for New 1977 and 1978 Model Year Gasoline-Fueled Heavy Duty Engines; Test Procedures

13. Section § 86.777–1 is revised to read as follows:

§ 86.777–1 General applicability.

The provisions of this subpart apply to new 1977 and 1978 model year

gasoline-fueled heavy duty engines.

14. New sections § 86.879–5 through § 86.879–14 are added to subpart I and read as follows:

§ 86.879–5 Test procedures.

The procedures described in this and subsequent sections will be the test program to determine the conformity of engines with the standard set forth in § 86.077–11(a).

(a) The test consists of a prescribed sequence of engine operating conditions on an engine dynamometer with continuous examination of the exhaust gases. The test is applicable equally to controlled engines equipped with means for preventing, controlling, or eliminating smoke emissions and to uncontrolled engines.

(b) The test is designed to determine the opacity of smoke in exhaust emissions during those engine operating conditions which tend to promote smoke from Diesel-powered vehicles.

(c) The test procedure begins with a warm engine which is then run through preloading and preconditioning operations. After an idling period, the engine is operated through acceleration and lugging modes during which smoke emission measurements are made to compare with the standards. The engine is then returned to the idle condition and the acceleration and lugging modes are repeated. Three sequences of acceleration and lugging constitutes the full set of operating conditions for smoke emission measurement.

(d) Except in cases of component malfunction or failure, all emission control systems installed on or incorporated in a new motor vehicle engine shall be functioning during all procedures in this subpart. Maintenance to correct component malfunction or failure shall be authorized in accordance with § 86.077–24.

§ 86.879–6 Diesel fuel specifications.

The requirements of this section are set forth in § 86.307.

§ 86.879–7 Dynamometer operation cycle for smoke emission tests.

(a) The following sequence of operations shall be performed during engine dynamometer testing of smoke emissions, starting with the dynamometer preloading determined and the engine preconditioned (§ 86.879–12(c)).

(1) *Idle mode.* The engine is caused to idle for 5 to 5.5 minutes at the manufacturer's recommended low idle speed. The dynamometer controls shall be set to provide minimum load by turning the load switch to the "off" position or by adjusting the controls to the minimum load position.

(2) *Acceleration mode.* (i) The engine speed shall be increased to 200±50 r.p.m. above the manufacturer's recommended low idle speed within 3 seconds.

(ii) Immediately upon completion of the mode specified in paragraph (a)(2)(i) of this section, the throttle shall be moved rapidly to, and held in, the fully-open position. The inertia of the engine and the dynamometer, or alternately a preselected dynamometer load, shall be used to control the acceleration of the engine so that the speed increases to 85 percent of the rated speed in 5±1.5 seconds. This acceleration shall be linear within 100 r.p.m. as specified in § 86.879–13(c).

(iii) After the engine reaches the speed required in paragraph (a)(2)(ii) of this section, but before the speed exceeds 90 percent of the rated speed, the throttle shall be moved rapidly to, and held in, the fully-closed position. Immediately after the throttle is closed, the preselected load required to perform the acceleration in paragraph (a)(2)(iv) of this section shall be applied.

(iv) When the engine decelerates to the intermediate speed (within 50 r.p.m.), the throttle shall be moved rapidly to, and held in, the fully-open position. The preselected dynamometer load which was applied during the preceding transition period shall be used to control the acceleration of the engine so that the speed increases to at least 95 percent of the rated speed in 10±2 seconds.

(3) *Lugging mode.* (i) Immediately upon completion of the preceding acceleration mode, the dynamometer controls shall be adjusted to permit the engine to develop maximum horsepower at rated speed. This transition period shall be 50 to 60 seconds in duration. During the last ten seconds of this period, the engine speed shall be maintained within 50 r.p.m. of the rated speed, and the power (corrected, if necessary, to rating conditions) shall be no less than 95 percent of the maximum horsepower developed at the zero-hour point.

(ii) With the throttle remaining in the fully-open position, the dynamometer controls shall be adjusted gradually so that the engine speed is reduced to the intermediate speed (within 50 r.p.m.). This lugging operation shall be performed smoothly over a period of 35±5 seconds. The rate of slowing of the engine shall be linear, within 100 r.p.m., as specified in § 86.879–13(c).

(4) *Engine unloading.* Immediately upon completion of the preceding lugging mode, the dynamometer and engine shall be returned to the idle condition described in paragraph (a)(i) of this section.

(b) The procedures described in paragraphs (a)(1) through (a)(4) of this section shall be repeated until three consecutive valid cycles have been completed. If three valid cycles have not been completed after a total of six consecutive cycles have been run, the engine shall be preconditioned by operation at maximum horsepower at rated speed for 10 minutes before the test sequence is repeated.

§ 86.879–8 Dynamometer and engine equipment.

The following equipment shall be used for smoke emission testing of engines on engine dynamometers.

(a) An engine dynamometer with adequate characteristics to perform the test cycle described in § 86.879–7.

(b) An engine cooling system having sufficient capacity to maintain the engine at normal operating temperatures during conduct of the prescribed engine tests.

(c) A noninsulated exhaust system extending 15±5 feet from the exhaust manifold, or the crossover junction in the case of Vee engines, and presenting an exhaust back pressure within ±0.2 inch Hg of the upper limit at maximum rated horsepower, as established by the engine manufacturer in his sales and service literature for vehicle application. A conventional automotive muffler of a size and type commonly used with the engine being tested shall be employed in the exhaust system during smoke emission testing. The terminal 2 feet of the exhaust pipe shall be circular cross section and be free of elbows and bends. The end of the pipe shall be cut off squarely. The terminal 2 feet of the exhaust pipe shall have a diameter in accordance with the engine being tested, as specified below:

Maximum rated horsepower:	Exhaust pipe diameter (inches)
Less than 101	2
101–200	3
201–300	4
301 or more	5

(d) An engine air inlet system presenting an air inlet restriction within ±1 inch of water of the upper limit for the engine operating condition which results in maximum air flow, as established by the engine manufacturer in his sales and service literature, for the engine being tested.

§ 86.879–9 Smoke measurement system.

(a) *Schematic drawing.* The Figure I79–1 is a schematic drawing of the optical system of the light extinction meter.

(b) *Equipment.* The following equipment shall be used in the system:

(1) Adapter—the smokemeter optical unit may be mounted on a fixed or movable frame. The normal unrestricted shape of the exhaust plume shall not be modified by the adapter, the meter, or any ventilator system used to remove the exhaust from the test site.

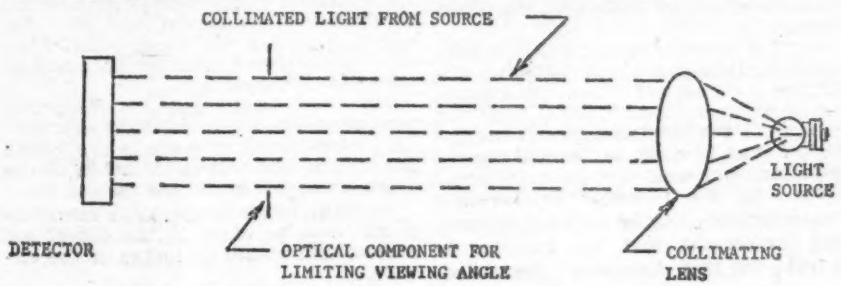

Figure I79–1 EPA SMOKEMETER OPTICAL SYSTEM (SCHEMATIC).

(2) Smokemeter (light extinction meter)—continuous recording, full-flow light obscuration meter. It shall be positioned near the end of the exhaust pipe so that a built-in light beam traverses the exhaust smoke plume which issues from the pipe at right angles to the axis of the plume. The light source is an incandescent lamp operated at a constant voltage of not less than 15 percent of the manufacturer's specified voltage. The lamp output is collimated to a beam with a nominal diameter of 1.125 inches. The angle of divergence of the collimated beam shall be within 4° included angle. A light detector, directly opposed to the light source, measures the amount of light blocked by the smoke in the exhaust. The detector sensitivity is restricted to the visual range and comparable to that of the human eye. A collimating tube with apertures equal to the beam diameter is attached to the detector. (It restricts the viewing angle of the detector to within 16° included angle.) An amplified signal corresponding to the amount of light blocked is recorded continuously on a remote recorder. An air curtain across the light source and detector window assemblies may be used to minimize deposition of smoke particles on those surfaces provided that it does not measurably affect the opacity of the plume. The meter consists of two units, an optical unit and remote control unit. Light extinction meters employing substantially identical measurement principles and producing substantially equivalent results but which employ other electronic and optical techniques may be used only after being approved in advance by the Administrator.

(3) Recorder—a continuous recorder, with variable chart speed over a minimal range of 0.5 to 8.0 inches per minute (or equivalent) and an automatic marker indicating 1-second intervals shall be used for continuously recording the exhaust gas opacity, engine rpm and throttle position. The recorder shall be equipped to indicate only when the throttle is in the full-open or fully-closed position. The recorder scale for opacity shall be linear and calibrated to read from 0 to 100 percent opacity full scale. The opacity trace shall have a resolution within 1 percent opacity. The recorder scale for engine r.p.m. shall be linear and have a resolution of 30 r.p.m. The throttle position trace must clearly indicate when the throttle is in the fully-open and fully-closed positions. Any means other than a strip-chart recorder may be used provided it produces a permanent visual data record of quality equal to or better than that described above.

(4) The recorder used with the smokemeter shall be capable of full-scale deflection in 0.5 second or less. The smokemeter-recorder combination may be damped so that signals with a frequency higher than 10 cycles per second are attenuated. A separate low-pass electronic filter with the following performance characteristics may be installed between the smokemeter and the recorder to achieve the high-frequency attenuation.

(i) 3 decibel point—10 cycles per second.

(ii) Insertion loss-zero ±0.5 decibels.

(iii) Selectivity—12 decibels per octave above 10 cycles per second.

(iv) Attenuation—27 decibels down at 40 cycles per second minimum.

(c) *Assembling equipment.* (1) The optical unit of the smokemeter shall be mounted radially to the exhaust pipe so that the measurement will be made at right angles to the axis of the exhaust plume. The distance from the optical centerline to the exhause pipe outlet shall be 5±1 inch. The full flow of the exhaust stream shall be centered between the source and detector apertures (or windows and lenses) and on the axis of the light beam.

(2) Power shall be supplied to the control unit of the smokemeter in time to allow at least 15 minutes for stabilization prior to testing.

§ 86.879–10 Information to be recorded.

The following information, as applicable, shall be recorded for each test.

(a) Engine Description and specifications. (1) Engine identification numbers.

(2) Number of hours of operation accumulated on engine.

(3) Engine-system combination.

(4) Engine displacement.

(5) Low idle r.p.m.

(6) Exhaust pipe diameter(s).

(7) Governed speed.

(8) Rated maximum horsepower and torque.

(9) Maximum horsepower and torque speeds.

(10) Fuel consumption at maximum power and torque

(11) Fuel injector type.

(12) Air aspiration system.

(13) Maximum exhaust system back pressure.

(14) Air inlet restriction.

(15) Maximum air flow.

(b) Test data. (1) Test number.

(2) Date and time of day.

(3) Instrument operator.

(4) Engine operator.

(5) Smokemeter: Number-zero control setting—calibration control setting—gain.

(6) Recorder chart: Identify zero traces—calibration traces—idle traces—closed throttle trace—open throttle trace—acceleration and lug down test traces—start and finish of each test.

(7) *Intake air humidity and temperature.* (i) Humidity conditioned air. Air that has had its absolute humidity altered is considered humidity conditioned air. For this type of intake air, the humidity measurement must be made within the intake air system, and after the air conditioning has taken place. Also, this measurement must be made within 48 inches of the engine.

(ii) Non-conditioned air. Humidity measurements in non-conditioned intake air systems must be made in the intake air stream and within 18 inches of the inlet for engine intake air system.

(iii) Intake air temperature measurement must be made in the intake air stream and within 48 inches of the engine.

(iv) Temperature and humidity devices must have a time constant τ, between 13 and 52 seconds. For a given instantaneous step change the measurement system must respond to 63.2% of that step change. If the temperature and humidity measurement systems have a time constant τ, less than 13 seconds, then the measurements will be sampled at a rate four or more times faster than the time constant τ and averaged. For continuously integrated intake air temperature systems, excursions exceeding the temperature limits for 30 seconds or less will be allowed.

(8) Dynamometer room temperature must be measured in two locations in the room within 10 feet of the engine. The two measurements are averaged. The measurement system must have a time constant, τ, between 13 and 52 seconds. For a given instantaneous step change the measurement system must respond to 63.2% of that step change. If the temperature measurement system has a time constant, τ less than 13 seconds, then the measurements will be sampled at a rate four or more times faster than the time constant τ and averaged. For continuously integrated dynamometer room air temperature systems, excursions exceeding the temperature limits for 30 seconds or less will be allowed.

(9) Barometric pressure, before and after test.

(10) Observed engine torque and speed during the steady-state test conditions specified in § 86.879–11(a)(3)(i).

(11) Calibration date(s) of neutral density filters used to calibrate the smokemeter.

§ 86.879–11 Instrument checks.

(a) The smokemeter shall be checked according to the following procedure prior to each test: (1) The optical surfaces of the optical section shall be checked to verify that they are clean and free of foreign material and fingerprints.

(2) The zero control shall be adjusted under conditions of "no smoke" to give a recorder trace of zero.

(3) Calibrated neutral density filters having approximately 10, 20, and 40 percent opacity shall be employed to check the linearity of the instrument. The filter(s) shall be inserted in the light path perpendicular to the axis of the beam and adjacent to the opening from which the beam of light from the light source emanates, and the recorder response shall be noted. The nominal opacity value of the filter will be confirmed by the Administrator. Deviations in excess of 1 percent of the nominal opacity shall be corrected.

(b) The instruments for measuring and recording engine r.p.m., engine torque, air inlet restrictions, exhaust system back pressure, throttle position, etc., which are used in the tests prescribed herein, shall be calibrated in accordance with good engineering practice. Neutral density filters shall be calibrated semi-annually.

§ 86.879–12 Test run.

(a) The temperature of the air supplied to the engine shall be between

68°F. and 86°F. The fuel temperature at the pump inlet shall be 100°F. ±10°F. The observed barometric pressure shall be between 28.5 inches and 31 inches Hg. Higher air temperature or lower barometric pressure may be used, if desired, but no allowance will be made for possible increased smoke emissions because of such conditions.

(b) The governor and fuel system shall have been adjusted to provide engine performance at the levels in the application for certification required under § 86.079–21.

(c) The following steps shall be taken for each test: (1) Start cooling system.

(2) Starting with a warmed engine, determine by experimentation the dynamometer inertia and dynamometer load required to perform the acceleration in the dynamometer cycle for smoke emission tests (§ 86.879–7(a)(2)). In a manner appropriate for the dynamometer and controls being used, arrange to conduct the acceleration mode.

(3) Install smokemeter optical unit and connect it to the recorder. Connect the engine r.p.m. and torque sensing devices to the recorder.

(4) Turn on purge air to the optical unit of the smokemeter, if purge air is used.

(5) Check and record zero and span settings of the smokemeter recorder at a chart speed of approximately 1 inch per minute. (The optical unit shall be retracted from its position about the exhaust stream if the engine is left running.)

(6) Precondition the engine by operating it for 10 minutes at maximum rated horsepower.

(7) Proceed with the sequence of smoke emission measurements on the engine dynamometer as prescribed in § 86.879–7.

(8) During the test sequence of § 86.879–7, continuously record smoke measurements, engine r.p.m., and throttle position at a minimum chart speed of 1 inch per minute during the idle mode and transitional periods and 8 inches per minute during the acceleration and lugging modes. The smokemeter zero and full scale recorder deflections may be rechecked during the idle mode of each test sequence. If either zero or full scale drift is in excess of 2 percent opacity, the smokemeter controls must be readjusted and the test must be repeated.

(9) Turn off engine.

(10) Check zero and reset if necessary and check span of the smokemeter recorder by inserting neutral density filters. If either zero or span drift is in excess of 2 percent opacity, the test results shall be invalidated.

§ 86.879–13 Chart reading.

The following procedure shall be used to analyze the recorder chart.

(a) Locate the modes specified in § 86.879–7 (a)(1) through (a)(4) by applying the following starting and ending criteria.

(1) The idle mode specified in § 86.879–7(a)(1) starts when engine preconditioning or the lugging mode of a preceding cycle has been completed and ends when the engine speed is raised above the idle speed.

(2) The acceleration mode specified in § 86.879–7(a)(2)(i) starts when the preceding idle mode has been completed and ends when the throttle is in the fully-open position as indicated by the throttle position trace.

(3) The acceleration mode specified in § 86.879–7(a)(2)(ii) starts when the preceding acceleration mode has been completed and ends when the engine speed reaches 85 percent of the rated speed.

(4) The transition period specified in § 86.879–7(a)(2)(iii) starts when the throttle is in the fully-closed position and ends when the throttle is in the fully-open position as indicated by the throttle position trace.

(5) The acceleration mode specified in § 86.879–7(a)(2)(iv) starts when the preceding transition period has been completed and ends when the engine speed reaches 95 percent of the rated speed.

(6) The transition period specified in § 86.879–7(a)(3)(i) starts when the preceding acceleration mode has been completed and ends when the engine speed is 50 r.p.m. below the rated speed and the provisions of § 86.879–7(a)(3)(i) are met.

(7) The lugging mode specified in § 86.879–7(a)(3)(ii) starts when the preceding transition period has been completed and ends when the engine speed is at the intermediate speed.

(b) Determine if the test requirements of § 86.879–7 are met by applying the following modal criteria.

(1) Idle mode as specified in § 86.879–7(a)(1): (i) Duration: 5 to 5.5 minutes.

(ii) Speed: within specifications.

(2) Acceleration mode as specified in § 86.879–7(a)(2)(i): (i) Duration: 3 seconds or less.

(ii) Speed increase: 200±50 r.p.m.

(3) Acceleration mode as specified in § 86.879–7(a)(2)(ii): (i) Linearity: ±100 r.p.m. as specified in paragraph (c) of this section.

(ii) Duration: 3.5 to 6.5 seconds.

(iii) Throttle position: fully-open until speed is at least 95 percent of the rated speed.

(4) Transition period as specified in § 86.879–7(a)(2)(iii): (i) Throttle position: fully-closed before speed exceeds 90 percent of the rated speed.

(5) Acceleration mode as specified in § 86.879–7(a)(2)(iv): (i) Duration: 8 to 12 seconds.

(ii) Throttle position: fully-open when speed is at intermediate speed.

(6) Transition period as specified in § 86.879–7(a)(3)(i): (i) Duration: 50 to 60 seconds.

(ii) Speed during last 10 seconds within ±50 r.p.m. of rated speed.

(iii) Corrected power during last 10 seconds: at least 95 percent of horsepower developed during zero-hour testing.

(7) Lugging mode as specified in § 86.879–7(a)(3)(ii): (i) Linearity: ±100 r.p.m. as specified in paragraph (c) of this section.

(ii) Duration: 30 to 40 seconds.

(iii) Speed at end: intermediate speed.

(c) Determine if the linearity requirements of § 86.879–7 were met by means of the following procedure: (1) For the acceleration mode specified in § 86.879–7(a)(2)(ii), note the maximum deflection of the r.p.m. trace from a straight line drawn between the starting and ending points specified in paragraph (a)(3) of this section.

(2) For the lugging mode specified in § 86.879–7(a)(3)(ii), note the maximum deflection of the r.p.m. trace from a straight line drawn from the starting and ending points specified in paragraph (a)(7) of this section.

(3) The test results will be invalid if any deflection is greater than 100 r.p.m.

(d) Analyze the smoke trace by means of the following procedure: (1) Starting at the beginning of the first acceleration, as defined in paragraph (a)(2) of this section, and stopping at the end of the second acceleration, as defined in paragraph (a)(3) of this section, divide the smoke trace into ½-second intervals. Similarly, subdivide into ½-second intervals the third acceleration mode and the lugging mode as defined by paragraphs (a)(5) and (7) respectively, of this section.

(2) Determine the average smoke reading during each ½-second interval.

(3) Locate and record the 15 highest ½-second readings during the acceleration mode of each dynamometer cycle.

(4) Locate and record the five highest ½-second readings during the lugging mode of each dynamometer cycle.

(5) Examine the average ½-second values which were determined in paragraphs (3) and (4) above and record the three highest values for each dynamometer cycle.

§ 86.879–14 Calculations.

(a) Average the 45 readings in § 86.879–13(d)(3) and designate the value as "A".

(b) Average the 15 readings in § 86.879–13(d)(4) and designate the value as "B".

(c) Average the nine readings in § 86.879–13(d)(5) and designate the value as "C".

15. The title to Subpart J is revised to read as follows:

Subpart J—Emission Regulations for New 1977 and 1978 Model Year Diesel Heavy Duty Engines; Gaseous Exhaust Test Procedure

16. Section § 86.977–1 is revised to read as follows:

§ 86.977–1 General applicability.

The provisions of this subpart apply to new 1977 and 1978 model year Diesel heavy duty engines.

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